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MEASURING AND ANALYZING COGNITIVE SKILLS AT THE PLATOON LEVEL

by

Michael G. Clark

March, 1990

Thesis Advisor: Samuel Parry

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Increasing budget restrictions require the Army to show that the policy of recruiting high quality people is paying dividends. The question is whether or not money being spent on better recruits is justified on the basis of combat efficiency. The measure of quality used in this research is the Armed Forces Qualification Test (AFQT) score. The higher the AFQT score the better the recruit.

Previous studies have found a strong correlation between mental ability and hands-on performance. The focus of this research is on the command and control or cognitive performance of the platoon leader. The method of investigating the relationship between cognitive skill and mental ability is to develop a tactical paper and pencil test and administer the test to a group of Non-Commissioned Officers from Fort Ord, California. The test is given once at the beginning of the Basic Non-Commissioned Officer Course of instruction and once at the end of the course.

The three objectives of this research are to determine which variables most influence decision making abilities, determine if a significant difference in decision making ability exists between mental categories and determine if training can make up for differences in decision making ability.

The results of the research show that AFQT scores are highly correlated with decision making ability, statistically significant differences exist between the decision making abilities of higher mental categories (CAT I and II) and lower mental categories (CAT IIIB and IV) and training does help make up for mental category differences Overall, mental category I leaders perform about 13% better than mental category IV leaders. In addition, training is able to raise the average score of lower mental category leaders by 8%.

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Measuring and Analyzing Cognitive Skills at the Platoon Level

by

Michael G. Clark
Captain, United States Army
B.S., United States Military Academy, West Point, NY

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Author: Michael G Clark
Michael G. Clark

Approved by: S H Parry
Samuel Parry, Thesis Advisor

Vic Roeske
Vic Roeske, Second Reader

P. Purdue
Peter Purdue, Chairman,
Department of Operations Research

ABSTRACT

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THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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I. INTRODUCTION AND BACKGROUND

A. COST AND NEED IN TERMS OF SOLDIER QUALITY

A subject of considerable controversy since the end of the Vietnam era revolves around the U.S. Army personnel structure in terms of soldier quality [Ref. 1]. Should the Army fill its ranks with only high quality people or should the Army be a microcosm of our society? Should the Army seek to optimize effectiveness by recruiting only high school graduates or be an equal opportunity employer? The debate is confounded by two very real, diametrically opposite problems: cost and need. The cost of recruiting and retaining only high quality soldiers is greater because the high quality recruit is less likely to join the Army and less likely to stay in unless there are incentives. The problem with incentives such as college education funds and enlistment/reenlistment bonuses is the expense. On the other hand, the fielding of sophisticated military hardware such as the M-1 Abrams tank and the M-2 Bradley Fighting Vehicle require a soldier who is mentally capable of dealing with complex equipment.

The debate on the quality issue is beyond the scope of this paper, but it does form the underlying framework for this research. Suffice it to say that the U.S. Army believes in recruiting the highest quality people available. The question is whether or not that policy is paying real dividends in terms of combat effectiveness. Are we in fact improving the Army by recruiting high quality people?

B. DEFINITION OF QUALITY

Soldiers that enlist in the Army are given a standardized paper and pencil test known as the Armed Services Vocational Aptitude Battery (ASVAB). ASVAB consists of ten cognitive tests which are combined to form composites. One composite is the Armed Forces Qualification Test (AFQT) which is used to classify recruits into mental categories. A recruit who scores in the upper percentiles of the AFQT is considered a high quality recruit. The relationship between mental category, AFQT score and reading level is shown in Table 1 below.

Throughout the paper the terms CAT I through CAT V are used to identify soldiers who fall into mental categories I through V as defined in Table 1.

Table 1. RELATIONSHIP OF MENTAL CATEGORY AND AFQT SCORE

Mental Category	AFQT Score	Reading Grade Level
I	93-100	12.7-12.9
II	65-92	10.6-12.6
IIIA	50-64	9.3-10.5
IIIB	31-49	8.1-9.2
IV	10-30	6.6-8.0
V	1-9	3.4-6.5

Throughout the paper the terms CAT I through CAT V are used to identify soldiers who fall into mental categories I through V as defined in Table 1.

C. THE PROBLEM

Increasing competition for budget dollars brings on the need to justify the costs and show the benefit of the All Volunteer Force in quantifiable terms. The ability to show that there is a positive correlation between a soldier's mental abilities and combat performance not only validates recruiting policy but gives insight on how much more efficient the force is, based on those policies.

Since the early 1980's, several studies have examined the relationship of mental category and performance. In most cases quality and performance were found to be highly correlated. In 1982 J. Wallace analyzed 1981 Canadian Army Trophy results and found a 0.74 correlation between the tank commander's AFQT score and his crew score during the competition [Ref. 2]. In 1984 B. Scribner (et al) published the results of their analysis of 1131 M-1 and M-60 Tank Table VIII scores from the ranges in Grafenwoehr, West Germany. Scribner, while looking at M-1 and M-60 tank commanders and gunners, found that CAT I commander gunner combinations performed 20% better than CAT IV combinations in the M-1 tank and 75% better when the crew was using an M-60 tank [Ref. 3]. Two studies concluded in 1989 found similar correlations. The Office of Economic and Manpower Analysis (OEMA) from West Point, New York found a 22% increase in performance between CAT IV and CAT I Bradley commander gunner combinations. Their analysis was based on 727 Bradley Table VIII firing results from Grafenwoehr [Ref. 4]. Also in 1989 the Fort Knox field unit of the U.S. Army Research Institute published the results of their combined field and SIMNET (short for Simu-

lation Network) test [Ref. 5]. They found tank commander and driver performance was highly related to mental category. In the field portion of their testing, CAT I and II soldiers performed 19% better than CAT IV. The SIMNET portion showed a 13% increase.

The studies to date show a strong correlation between performance and mental ability but this measure of performance is limited to individual or crew level skills. For example, it can be said that we are 95% confident that a CAT I crew will perform about 20% better than a CAT IV crew. We cannot however say that the tactical unit led by a CAT I commander will perform 20% better than the CAT IV led unit. Combat performance is more than just the sum of the physical skills of the unit. Performance is also a function of the cognitive or "thinking" skills within the unit and particularly the skills of the leadership.

The focus of this paper is on the platoon level of organization. The question to be answered is whether or not mental ability has an effect on decision making ability. The three objectives of this research are to:

- Determine which variables influence decision making ability.
- Determine if a significant difference in tactical decision making ability exists between mental categories.
- Determine if training can make up for differences in decision making ability.

D. METHODOLOGY

The investigation of the cognitive abilities of the platoon leader is divided into five phases:

- Phase 1 - Design a cognitive skills test that places the leader in a combat scenario where he must make decisions. At each decision opportunity, several decision alternatives are offered. Each alternative is numerically weighted according to the potential impact it will have on the successful accomplishment of the platoon mission. Weighting of the alternatives is the method used to score the test, with a higher score meaning a higher probability of success. The weighting scheme is based on expert opinion and the test score is a measure of how well the leader makes decisions and thus is a measure of combat effectiveness.
- Phase 2: Collect an initial data set at the beginning of the Basic Non-Commissioned Officer Course (BNCOC) of instruction at Fort Ord, California. The test population consists of the Non-Commissioned Officers attending the course. The data set consists of the dependent variable ***Total Score*** and five independent variables: AFQT score, time in service, time in grade, time required to complete the test and Military Occupation Skill (MOS).
- Phase 3: Analyze the first data set to determine if there is a significant difference between mental category average scores.

- Phase 4: Collect a second set of data at the end on the course of instruction from the same test population using the same test.
- Phase 5: Analyze the second data set to determine if training has any influence on test scores.

II. TEST DESIGN AND SCORING SYSTEM

A. TEST SCENARIO

1. Purpose

The ***Platoon Level Cognitive Skills Test (PLCST)*** is a surrogate for more complicated data gathering devices. Two such devices are the Simulation Network (SIMNET) system and the JANUS model. SIMNET is the latest in state-of-the-art battle simulators. It allows the crew of one simulator to see and react to other simulators through a computer network. The simulators are manned by actual soldiers who fight against each other and not against the computer. The system is currently capable of networking together a battalion size unit and collecting individual data on each vehicle in the battalion [Ref. 6]. The JANUS model is also an interactive computer driven simulator that allows one operator to plan and control an entire unit from a single keyboard. The data produced by this model are reflections of the operator's command and control abilities rather than the combined abilities of all crews as in SIMNET. Use of sophisticated battle simulators such as SIMNET and JANUS is the desired method of collecting data because of the level of sophistication. However, they are not always the most practical. SIMNET, for example, requires thousands of dollars and a minimum of eighteen months advance notice to reserve. Both SIMNET and JANUS require substantial train-up time for test subjects. The PLCST uses a paper and pencil approach to gathering data. It is a logical surrogate for other collection methods not only because of its low cost and short lead time, but because this is a pilot test. The ability to collect reliable cognitive data in this manner must first be shown before large amounts of money and time are committed.

2. Contents

The PLCST contains three basic parts: a general situation, ten special situations and a short questionnaire. The general situation is designed to orient the test subject to the overall battlefield environment. He is told that he is now a platoon leader, given his current unit status and an outline of the upcoming mission. The most important aspect of the general situation, however, is the guidance given to the leader. In the PLCST guidance follows the format commonly referred to as METT-T [Ref. 7 : p. 120]. This acronym is defined in Figure 1 on page 6.

Mission - the goal or objective assigned to a unit.
Enemy - the size, type, and disposition of the opposing force.
Troops Available - the size, type, and disposition of the friendly force.
Terrain and Weather - the local topography and climatic conditions.
Time - an estimate of the length of time necessary to conduct the operation.

Figure 1. METT-T Definition

In order to ensure uniformity of interpretation, the factors of METT-T are ranked according to how important they are to the mission at hand. This ranking is explained to the leader in the general situation. Because of the difficulty in simulating terrain in this type of test it is held constant. The platoon leader is told in the general situation that terrain will not effect his mission. For the purposes of this test, the factors of METT-T in descending order of importance are:

1. Mission
2. Troops Available
3. Time
4. Enemy
5. Terrain

The second portion of the test consists of the ten independent special situations. Each special situation places the platoon leader in a tactical circumstance that requires him to exercise his decision making skills. The leader receives enough information in the general and special situations to allow him to make a reasonable decision. He must sort through the information provided, select what he feels is important and choose the best tactical course of action. Accompanying each of the ten special situations are four alternative courses of action. The platoon leader must choose the best course, i.e., the one that will lead to successful accomplishment of his mission with the least potential casualties in the least amount of time.

The test is not a free play exercise because of the need to maintain an audit trail on the responses. Free play means allowing the platoon leader the freedom to choose

his own decision rather than restrict his choice of the number of decisions to four. With free play there is the requirement to score what could easily amount to hundreds of different alternatives. In order to keep the test manageable, the number of alternatives available is fixed.

The final portion of the test is a short questionnaire that provides the minimum necessary information to conduct the data analysis. The soldier is asked to provide his rank, time in service, time in grade and social security number that is used to match AFQT scores. The entire test packet, as presented to the test subjects, is found in Appendix A.

3. Special Considerations

An important aspect of the design of the test is to ensure to the maximum extent possible that each decision is independent of all others. Dependent decisions result in the possibility of an exponential number of paths through the scenario. With four alternatives per decision there would be 2^8 different alternatives by the time the fourth decision must be made. Keeping track of that many alternatives quickly becomes unmanageable. It is possible to make the decisions independent by carefully wording each special situation.

Another design consideration is level of difficulty associated with each decision. Care must be taken to include in each alternative only the assets that a platoon leader would reasonably be expected to manage. This is important because a decision based on an unfamiliar set of circumstances amounts to a mere guess.

Finally, care must be taken not to give the platoon leader too much information. He must not be lead toward the best solution nor should the best solution be obvious. Each decision must be made with the minimum amount of information necessary or the test scores will be biased.

B. SCORING SYSTEM

1. Purpose

The purpose of the scoring system is to quantify the responses made by each leader. In order to grade the decisions made, one must have some knowledge of what is most likely to happen if that decision is implemented. Unfortunately, the solution to this problem cannot be derived neatly in a mathematical formula. Instead, the solution is to seek the expert opinion of someone who has a great deal of experience in tactical decision making.

LTC Charles Swannack has over 20 years of experience as an infantryman, most of those years in the light infantry. LTC Swannack has served as a rifle platoon leader, scout platoon leader and rifle company executive officer in the Berlin Brigade. LTC Swannack's command tours include a company command in the 1st Battalion (Airborne), 508th Infantry, 82nd Airborne Division, and his current assignment as commander of the 2nd Battalion, 9th Infantry (Light) at Fort Ord, California, where his most recent experience was combat duty in Panama. He wears the Combat Infantryman's Badge, Master Parachutist Badge and Ranger Tab and is eminently qualified to evaluate the alternatives in this test.

2. Weighting System

The weighting system for the PLCST is based on the factors of METT-T. Weights are determined by assigning a value to each factor from the scale in Figure 2. Note that one is the lowest score and five the highest. The total score for each alternative is the sum of the weighted factors of METT-T. Again, since terrain is difficult to simulate in a paper and pencil test, that factor is not considered in this scenario.

1----------2----------3----------4----------5

1 = Course of action will have a strong negative effect on this factor.

2 = Course of action will have a moderate negative effect on this factor.

3 = Course of action will have no effect on this factor.

4 = Course of action will have a moderate positive effect on this factor.

5 = Course of action will have a strong positive effect on this factor.

Figure 2. Test Weighting Scale

3. Results

A summary of the scores by alternative are in Table 2 below. The complete scoring system by weighted factor is in Appendix B. The maximum number of points possible for the test is 150.

Table 2. SCORING SYSTEM RESULTS

Decision	Alternative 1 Score	Alternative 2 Score	Alternative 3 Score	Alternative 4 Score
A	13	6	12	16
B	14	9	10	6
C	6	5	14	15
D	15	12	11	9
E	13	7	16	11
F	9	12	14	12
G	15	10	15	17
H	9	12	10	12
I	13	12	10	7
J	7	11	9	14

III. DESCRIPTION OF DATA SETS AND TEST ADMINISTRATION

A. GENERAL

1. Use of Two Sets of Data

Two data sets are necessary not only to show that mental ability is highly correlated with command and control abilities, but to show whether or not programs such as BNCOC are positively influencing cognitive skills. The initial set of data is collected at the beginning of the BNCOC course and will be analyzed to determine if a significant difference in tactical decision making ability exists between mental categories. The second set is collected toward the end of the course after all of the tactics instruction has been given. The second set allows for a comparison of test scores to determine whether or not BNCOC improves decision making skills. The question is whether or not training can reduce mental ability differences.

2. Data Set Composition

The data sets consist of the total test scores and certain relevant individual information that is thought to influence decision making ability. The dependent variable is the total score achieved on the test by each platoon leader. Total score is the sum of the points associated with the chosen alternatives based on LTC Swannack's scoring system. This score is a measure of how well a leader makes decisions. It is also an indicator of consistency in that the leader who scores high on the test is applying the factors of METT-T consistently to the problems presented throughout the test.

There are countless variables that influence how a person makes decisions such as environmental factors, individual personality traits and daily stress. The intent of this paper is to select a subset of variables that are thought to influence tactical decision making and analyze those using regression and nonparametric analysis techniques. The specific independent variables are the following: raw mental ability measured by AFQT score, experience level measured by time in service and time in grade (in years served), time required to complete the test (in minutes), and Military Occupational Skill (MOS). The time required to complete the test is included as an independent variable because it is thought that as time to complete increases, the total test score will increase. Basically, the more time a person takes to think about a problem, the better his or her decision is apt to be.

The data sets are complete in that each test has a one-to-one match with AFQT score and the correct experience and MOS data. The complete data set matrix is in Appendix C. Table 3 below is a summary of the variables.

Table 3. DATA SET SUMMARY BY MENTAL CATEGORY

Variable	CAT I	CAT II	CAT IIIA	CAT IIIB	CAT IV
Avg Score First Test	130	127	122	118	114
Avg Score Second Test	134	124	127.8	127.3	126.6
Avg AFQT Score	95.7	74.1	56.8	39.0	18.8
Avg Time in Service (Yrs)	7.6	5.7	6.1	5.5	6.5
Avg Time in Grade (Yrs)	2.7	1.3	2.2	1.4	2.0
Avg Time to Complete First Test (Min)	20.3	20.9	16.3	18.3	21.0
Number Tested First Test	3	7	4	9	6
Number Tested Second Test	3	6	4	7	5

In addition, the categorical variable MOS consists of 18 infantrymen (MOS 11B), 6 artillerymen (MOS 13B), and 5 engineers (MOS 12B).

B. TEST ADMINISTRATION

1. Sample Population

The test scores are from 29 Non-Commissioned Officers (NCOs) attending the 7th Infantry Division (Light) Basic Non-Commissioned Officer Course (BNCOC). The decision to use NCOs is based on the need to measure mental ability. Since enlisted soldiers have AFQT scores as a part of their permanent records, it is a simple task to match a test score with mental aptitude. The choice of NCOs as the test population is consistent not only with the level of the test (platoon level), but with common expectations concerning NCOs. The BNCOC students in the test population are expected to be able to take on additional responsibility and make good decisions. On the modern battlefield, many will be called upon to perform the duties of the platoon leader soon after the battle begins. It is therefore not unusual to treat the NCO exactly as one would an officer at the platoon level.

2. Test Environment and Collection Technique

Another important reason for selecting BNCOC students to form the test population is the need to reduce as many potential sources of variation as possible. In a typical tactical unit, the daily schedule rarely permits an experimenter access to the unit's entire NCO complement. Since BNCOC is a resident course, the students are away from their parent unit and the experimenter has in effect a "captive" audience. Another important potential source of variance when testing people is motivation. If a tactical unit is used as the test population, the range of motivation within the NCO corps would undoubtedly be large. With BNCOC students there is little problem with motivation because the soldiers who attend the course are hand-picked by their commander and senior NCOs. The fact that the individual is in the course is evidence of his high motivation and demonstrated desire to excel.

Perhaps the most concerning source of potential bias is the BNCOC environment itself. The strict code of conduct at the school generally does not allow a student to volunteer for such things as taking cognitive tests. The student basically does what he is told. As a result, the test could very easily be biased by forced participation. In this case, all test subjects were given the choice of taking the PLCST or using that hour for other school related study. All 29 students volunteered to take the test. Additionally, the BNCOC instructors were not allowed in the room during the test to further reduce any bias they may inadvertently cause by their presence.

Another important factor that the use of BNCOC students allows is a random draw from the NCO population of the west coast area of the United States. Of the 29 soldiers in the data set, 26 are from different units ranging from Fort Wainwright, Alaska to Fort Irwin, California. Bias in the test scores due to unit peculiar training methods is therefore reduced by this random sample of NCOs.

IV. DATA ANALYSIS

A. THREE PART ANALYSIS

The analysis of the data collected for this paper is separated into three distinct parts, each corresponding to one of the three prime objectives of the research. The first part is a multi-linear regression model that is designed to identify which of the selected variables most influence decision making ability. The second part is an analysis by mental category of the test scores from the first test. The object is to determine if a statistically significant difference exists between different mental categories. The third part of the analysis is a comparison between pre-tactics training and post-tactics training test scores to determine if a statistically significant difference exists. This third analysis will show whether or not training can reduce mental categories differences.

B. MULTIVARIATE REGRESSION MODEL

The data generated by the test requires extension of the simple linear regression model because there is more than one independent variable under consideration. The data forms a $29 X 6$ matrix where the first column is the i^{th} response to the i^{th} set of five independent variables. Each row in the matrix represents one data point. The matrix itself is in the form:

$$\begin{bmatrix} y_1 & x_{11} & x_{12} & x_{13} & x_{14} & x_{15} \\ y_2 & x_{21} & x_{22} & x_{23} & x_{24} & x_{25} \\ y_3 & x_{31} & x_{32} & x_{33} & x_{34} & x_{35} \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ y_i & x_{i1} & x_{i2} & x_{i3} & x_{i4} & x_{i5} \end{bmatrix}$$

The matrix forms a ***Multi-Linear Regression*** situation under the assumption that the outputs (y_i), are linearly related to their corresponding independent variable inputs (x_i) in the region of those inputs [Ref. 8 p. 51].

In matrix notation, the model can now be formulated as:

$$\mathbf{y} = \mathbf{X}\,\beta + \mathbf{E}$$

where

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \cdot \\ \cdot \\ \cdot \\ y_i \end{bmatrix} \quad \mathbf{X} = \begin{bmatrix} 1 & x_{11} & x_{12} & x_{13} & x_{14} & x_{15} \\ 1 & x_{21} & x_{22} & x_{23} & x_{24} & x_{25} \\ 1 & x_{31} & x_{32} & x_{33} & x_{34} & x_{35} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 1 & x_{i1} & x_{i2} & x_{i3} & x_{i4} & x_{i5} \end{bmatrix} \quad \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \\ \beta_5 \\ \beta_i \end{bmatrix} \quad \mathbf{E} = \begin{bmatrix} \varepsilon_0 \\ \varepsilon_1 \\ \varepsilon_2 \\ \cdot \\ \cdot \\ \cdot \\ \varepsilon_i \end{bmatrix}$$

The model is a function of the product of the independent variables and their estimated coefficients plus model error.

1. Model Assumptions

In addition to assuming the dependent and independent variables are linearly related, the model requires three other important assumptions [Ref. 8 p. 51]:

- The x_i are not random and are measured with negligible error.
- The model errors, (ε_i) are random, normally distributed variables with mean zero and constant variance. These errors are also uncorrelated from observation to observation.
- Any random variation in x is small compared to the measurement range.

2. Backward Stepwise Regression Technique

In order to determine which of the five independent variables has the most influence on the platoon level cognitive test score, a technique called backward stepwise regression is employed. With this technique the initial regression is performed with all of the variables in the model. The regression program [Ref. 9] then eliminates one variable at a time until only significant variables remain. The variable selected for removal is the one that reduces the model's R^2 value the least and thus it is the variable with the smallest partial F-statistic. In this way the variable with the least significance is removed systematically from the model until only highly influential variables remain. Criterion for removal is based on significance level. A variable must have a significance level

greater than 0.1 for it to be removed from the model. Table 4 below shows the result of backward stepwise regression on the data set. Note that the far right column indicates the set of variables included in the model at each step. The list below shows the relationship of the independent variables and the numbering code used by the GRAFSTAT regression program.

- 0 = Y-axis intercept
- 1 = AFQT Score
- 2 = Time in Service (TIS)
- 3 = Time in Grade (TIG)
- 4 = Time to Complete Test (TIME)
- 5 = MOS

Table 4. BACKWARD STEPWISE HISTORY

Variable	Action	F Value	α Level	Subset
TIG	Delete	0.0055	0.0586	0 1 2 4 5
MOS	Delete	0.2366	0.3689	0 1 2 4
TIS	Delete	0.3482	0.4396	0 1 4
TIME	Delete	0.3384	0.4342	0 1

The backward regression technique clearly identifies AFQT as the most influential variable in the model. At this point all other variables thought to influence decision making skills have been tested for significance and removed from the model. The model is therefore reduced to a simple linear regression model with AFQT as the only remaining independent variable. The model now can be written as:

$$y = \beta_0 + \beta_1 X_1 + E$$

A complete set of backward stepwise regression diagnostics can be found in Appendix D.

3. AFQT Regressed on Test Score

In the previous section backward regression showed AFQT to be highly influential in determining cognitive test scores. The question now is whether or not the slope of the regression line determined by AFQT alone, is significantly different from zero.

To show that there is a statistical difference, an ordinary least squares regression is conducted using AFQT as the sole independent variable. A straight line is fit to the 29 test scores and an AVOVA is performed to determine if the null hypothesis should be accepted. In this case the null and alternate hypotheses are;

$$H_0 : \textit{The slope is zero}$$

$$H_1 : \textit{The slope is greater than } 0$$

The AVOVA in Table 5 below indicates that the null hypothesis is rejected at an alpha level of 0.05. This indicates that as AFQT score increases, decision making ability also increases. A graphical representation of the regression is shown in Figure 3 on page 17 where AFQT is plotted on the x-axis and total test score on the y-axis.

Table 5. AVOVA AFQT VERSUS COGNITIVE TEST SCORE

Source	DF	SS	MS	F	F(1,27)	α Level
AFQT	1	1147.40	1147.40	34.99	1.38	0.05
Error	27	885.30	32.79			
Total	28	2032.70				

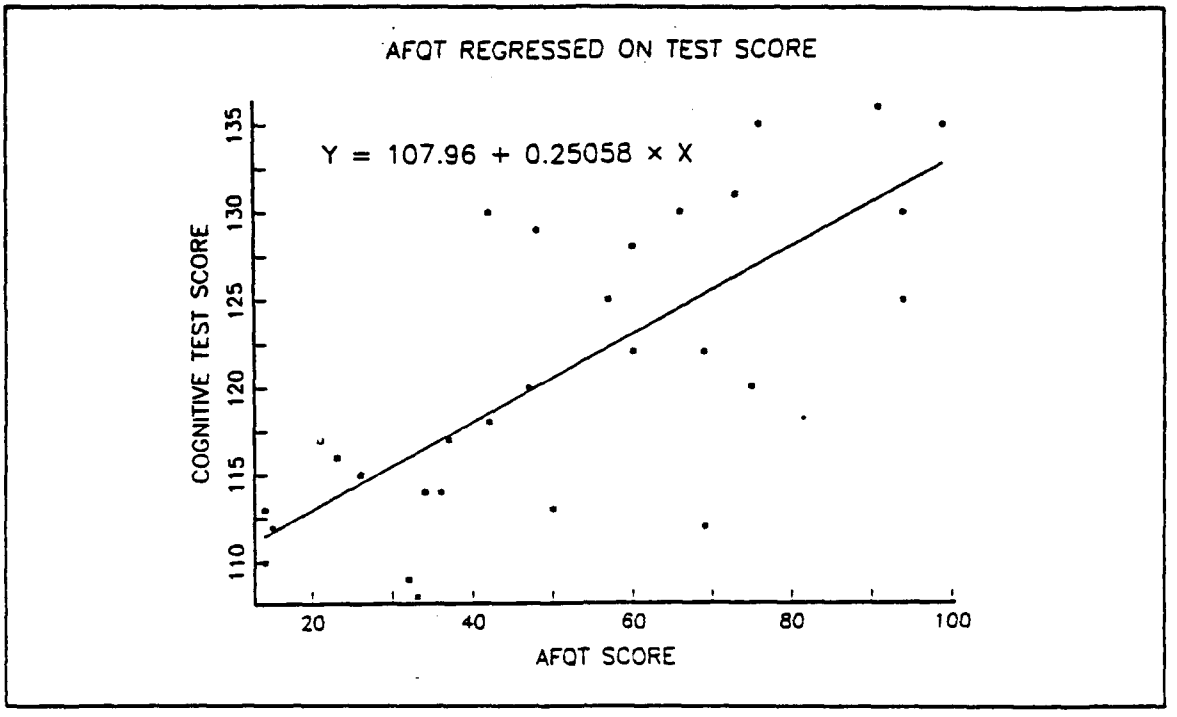


Figure 3. AFQT Regressed on Test Score

An important point concerning the regression should be made here. A common measure of variance explained by a model is R^2. In this model $R^2 = 0.5646$ which would seem to be low. However, since the model is not used to predict test scores, this value is actually very high. It means that the single variable AFQT accounts for more than half the observed variability. When put into perspective, this R^2 is actually 12% greater than those achieved in previous studies. For example the Army Research Institute study mentioned in chapter one achieved an R^2 of 0.44 when regressing AFQT on their particular test score [Ref. 5 : p. 35]. The indication is that mental ability plays an even more important role when the issue is command and control.

4. Residual Analysis

The degree to which the results from the model deviate from the observed data can be shown using residual analysis. The purpose is to determine if the assumptions which form the backbone of the regression, e.g. constant variance, have been violated. If this is the case, then any statement concerning AFQT and test scores would be invalid. Figure 4 on page 18 is a plot of the residuals against their fitted values ($\hat{y}$).

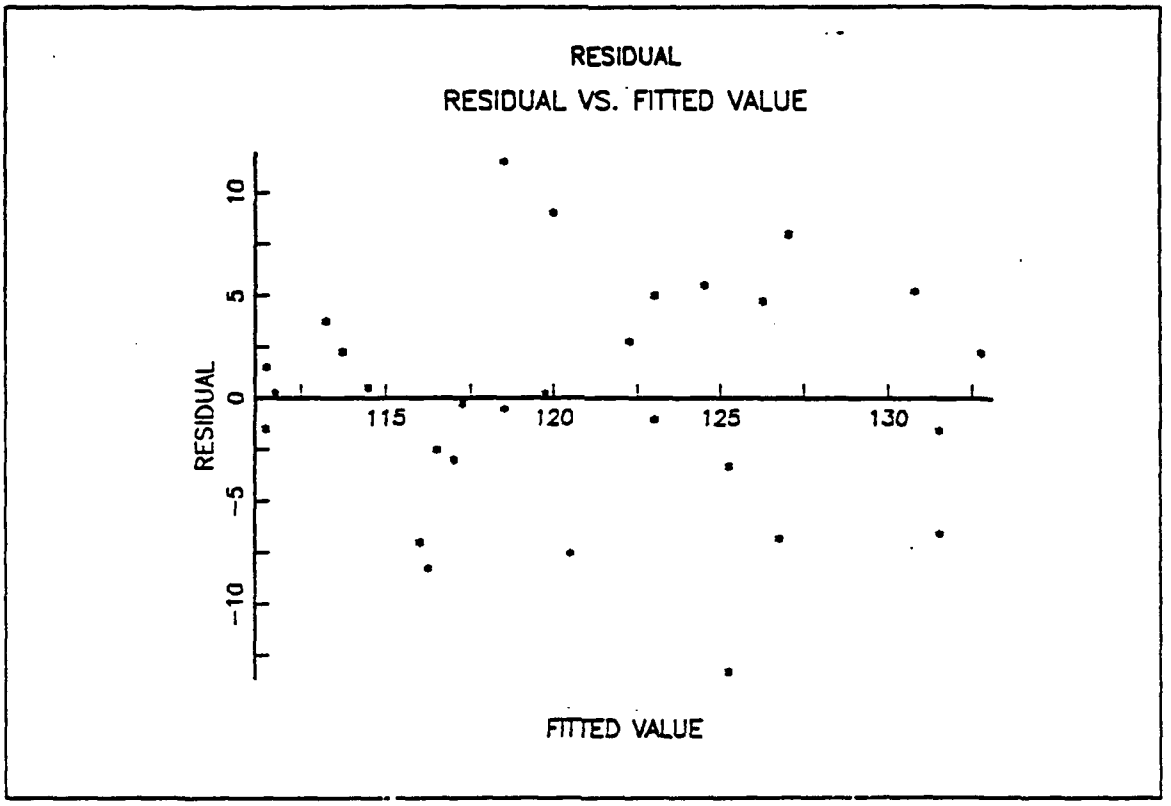


Figure 4. Residual Plot

The plot indicates that the model is not underspecified and that the constant variance assumption has not been violated. Additionally, since least squares estimators perform better under the normality assumption [Ref 8 : p. 55], the residuals are fit to a normal distribution. Because of the relatively small data size, the Kolmogorov goodness-of-fit test is used to evaluate fit. The null and alternate hypotheses are;

H_0 : *The residuals fit a normal distribution*

H_1 : *The residuals are not from a normal distribution*

The Kolmogorov statistic in this case is *0.0877* compared to the theoretical value ***0.2460*** Since the computed value is less than the theoretical, H_0 cannot be rejected and the residuals are from a normal distribution. This indicates that the model assumptions and results are valid. Complete residual plots and statistics are in Appendix E.

C. ANALYSIS OF TEST SCORES BY MENTAL CATEGORY

Having first shown that AFQT is a highly influential variable, the next phase of the analysis is to investigate whether or not there is a statistically significant difference in score between mental categories. This analysis consists of three elements:

- Separating the test scores into mental categories and computing category averages.
- Testing these mental category average scores using the Kruskal-Wallis test to determine if there are significant differences between the category averages.
- Performing a multiple comparison test to determine exactly which mental category averages are statistically different.

1. Average Score by Mental Category

Figure 5 is a graphic portrayal of the average test score by mental category.

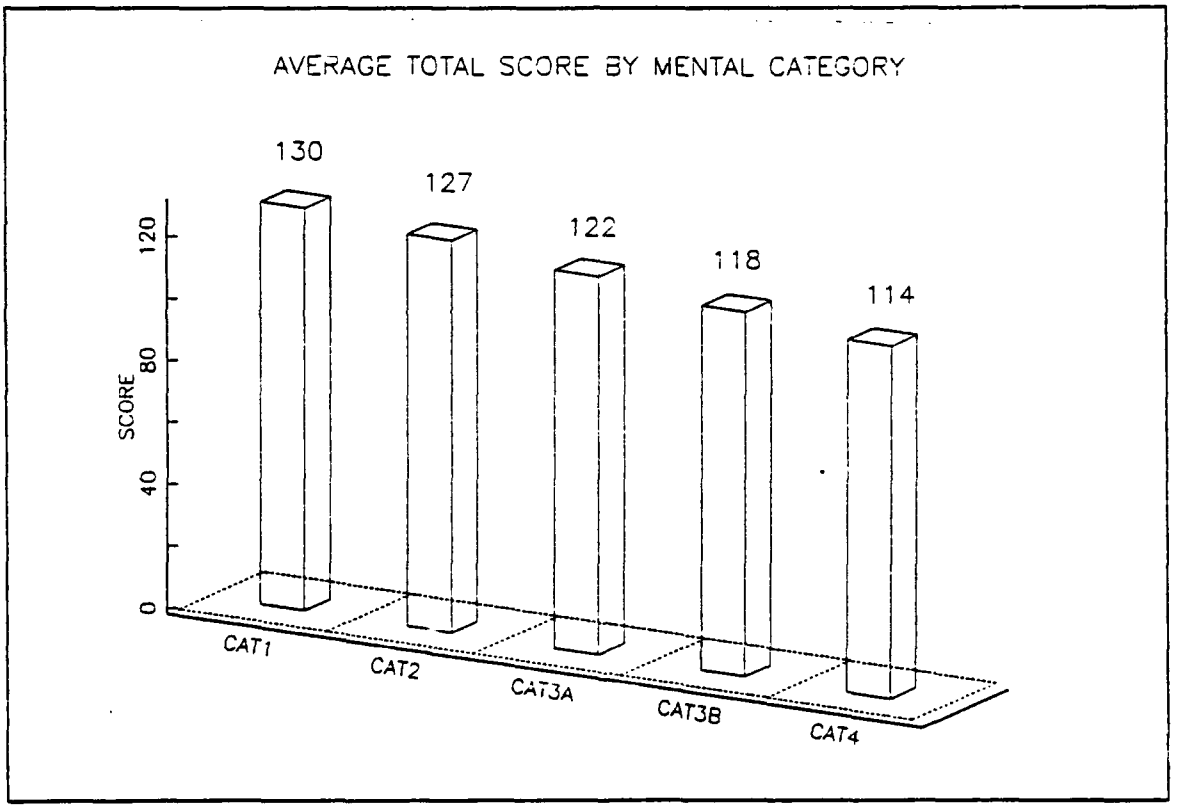


Figure 5. Average Score by Mental Category

It is clear from the figure that CAT I leaders perform better than any other mental category group. A comparison of the performance of lower mental categories relative to CAT I is in Table 6. The percentages are the ratio of the mental category average score to the average score achieved by CAT I leaders, times 100.

Table 6. PERFORMANCE RELATIVE TO CAT I

Mental Category	I	II	IIIA	IIIB	IV
Relative to CAT I	100%	97%	93%	90%	87%

2. Kruskal-Wallis Test for Different Population Averages

To statistically show that there is a difference between mental category average scores, the nonparametric test attributed to Kruskal and Wallis is used [Ref. 10: p. 229]. There are five different populations represented by each of the five AFQT mental categories. Since each population has a different number of observations (as seen in Table 3 on page 11) and because no assumption of normality is being made, the Kruskal-Wallis test is appropriate. Each test score is assigned a rank $R(X_{ij})$ from the lowest score to the highest. Figure 6 shows the result of this ranking scheme. Tie scores receive equal rank.

	CAT I		CAT II		CAT IIIA		CAT IIIB		CAT IV	
	Obs	Rank	Obs	Rank	Obs	Rank	Obs	Rank	Obs	Rank
	125	19.5	130	24	122	17.5	114	8.5	112	4.5
	130	24	120	15.5	113	6.5	109	2	113	6.5
	135	27.5	131	26	128	21	114	8.5	110	3
			122	17.5	125	19.5	117	12.5	117	12
			136	29			118	14	116	11
			112	4.5			130	24	115	10
			135	27.5			108	1		
							129	22		
							120	15.5		
Sum of Ranks		77		144		64.5		108		47.5
Number of Obs		3		7		4		9		6
Total Observations		29								

Figure 6. Kruskal-Wallis Ranks

These ranks are then summed over the population. Mathematically, the equation is:

$$R_i = \sum_{j=i}^{n_i} R(X_{ij}) \quad for\ all\ i$$

Since the Kruskal-Wallis test is sensitive to differences between population means, the null and alternate hypotheses under consideration are stated as:

H_0 : *All five mental categories have the same mean*

H_1 : *The five categories have different means*

The Kruskal-Wallis test statistic is given as:

$$T = \frac{1}{S^2}\left(\sum_{i=1}^{5}\frac{R_i^2}{n_i}\right) - \left(\frac{N(N+1)^2}{4}\right) \tag{1}$$

where

$$S^2 = \frac{1}{N-1}\left(\sum_{i=1}^{29} R(X_{ij})^2\right) - \left(\frac{N(N+1)^2}{4}\right) \tag{2}$$

In equation (1), n_i is the number of observations in each mental category. N in equations (1) and (2) is the sum of all n_i. The computed Kruskal-Wallis statistic from the cognitive skill test is ***11.48*** while the theoretical Chi-square statistic, at the 0.05 level of significance, with four degrees of freedom is ***9.49***. Since the Kruskal-Wallis statistic is greater than the theoretical, the null hypothesis is rejected and there is a statistical difference between mental category average scores.

3. Multiple Comparison Test

To determine exactly which population means differ, a multiple comparison test is performed using the following equation [Ref. 10: p. 231].

$$\left|\frac{R_i}{n_i} - \frac{R_j}{n_j}\right| > t_{1-(\alpha/2)}\left(\sqrt{S^2\frac{N-1-T}{N-k}}\right)\left(\sqrt{\frac{1}{n_i}+\frac{1}{n_j}}\right) \tag{3}$$

In equation (3), $t_{1-(\alpha/2)}$ is the $(1-\alpha/2)$ quantile of the t distribution with $N-k$ degrees of freedom. S^2 is from equation two, T is from equation one and k is the total number of mental categories. A comparison using this equation can be made between each pair of mental categories. The APL function that computes all of the pair-wise comparisons is in Appendix F, and a summary of the results is in Table 7 below.

Table 7. MENTAL CATEGORY COMPARISONS

Mental Category	$\left\lvert \frac{R_i}{n_i} - \frac{R_j}{n_j} \right\rvert$	$t_{1-(\alpha/2)}\left(\sqrt{S^2 \frac{N-1-T}{N-k}}\right)\left(\sqrt{\frac{1}{n_i}+\frac{1}{n_j}}\right)$
I vs. II	3.09	10.64
I vs. IIIA	7.54	11.77
I vs. IIIB	11.67	10.28
I vs. IV	15.75	10.90
II vs. IIIA	4.45	9.66
II vs. IIIB	8.57	7.77
II vs. IV	12.65	8.58
IIIA vs. IIIB	4.13	9.26
IIIA vs. IV	8.21	9.95
IIIB vs. IV	4.08	8.12

In the above table, when the value in the center column is greater than the value in the right column, the mental categories being compared are said to be different. In this case, the average test scores of CAT I and II leaders differ statistically from both CAT IIIB and IV. CAT IIIA average test scores do not differ statistically from either the higher mental categories (CAT I and II) or from the lower mental categories (CAT IIIB and IV).

D. ANALYSIS OF TRAINING IMPACT ON TEST SCORES

The first part of this portion of the analysis considers the entire test population which consists of both the pre-tactics training and the post-tactics training sets of test scores. The object is to show whether or not there is a difference between the overall mental category average scores on the first test and the overall mental category average scores on the second test. The second part addresses CAT IIIB and CAT IV mental categories only because the object is to determine if training can make up for lower test scores which are associated with CAT IIIB and IV leaders. If the second test scores are consistently higher, then at least some of the credit can be attributed to the BNCOC instruction.

To determine if a significant difference exists between scores on the first test (administered at the beginning of BNCOC) and the second test (administered six weeks later at the end of the course), the nonparametric Mann-Whitney test is used [Ref. 10: p. 216]. The data consists of two independent samples, the first of size $n = 29$ and the second of size $m = 25$. The reason the second test sample size is smaller is that four students who took the first test were not available for the second. Ranks from one to 54 are assigned to the entire data set. Let $R(X_i)$ and $R(Y_j)$ denote the ranks assigned to the first and second test scores, respectively. Figure 7 shows the two sets of test scores (labeled X and Y) and the rank assigned to each. Tie scores receive equal ranking.

X	RANK	Y	RANK	X	RANK	Y	RANK
108	1	117	13	120	21	128	34.5
109	2	118	15.5	122	26.5	130	39
110	3	119	17	122	26.5	130	39
112	4.5	120	21	125	31	131	42.5
112	4.5	120	21	125	31	133	45.5
113	6.5	120	21	128	34.5	133	45.5
113	6.5	120	21	129	36	133	45.5
114	8.5	120	21	130	39	133	45.5
114	8.5	122	26.5	130	39	136	50.5
115	10	122	26.5	130	39	138	52.5
116	11	124	29	131	42.5	138	52.5
117	13	125	31	135	48.5	144	54
117	13	127	33	135	48.5		
118	15.5			136	50.5		
120	21						

Figure 7. Mann-Whitney Ranks

The desire is to test whether or not the second test has an average greater than the first test. The null and alternate hypotheses are thus:

$$H_0 : E(X) \geq E(Y)$$

$$H_1 : E(X) < E(Y)$$

which represent a one-sided Mann-Whitney tests for differences in two population averages. The test statistic of interest is computed by summing the ranks assigned to the first test scores.

$$T = \sum_{i=1}^{29} R(X_i)$$

Since there are many tied scores in the data, this statistic must first be normalized by subtracting the mean from T and dividing by the standard deviation [Ref. 10 : p. 217].

$$T_1 = \frac{T - n\frac{N+1}{2}}{\sqrt{\frac{nm}{N(N-1)}}\sqrt{\sum_{i=1}^{N} R_i^2} - \sqrt{\frac{nm(N+1)^2}{4(N-1)}}} \qquad (4)$$

where $\sum_{i=1}^{N} R_i^2$ is the sum of the squared ranks of both sets of data, and $N = n + m$.

When the values of n and m are greater than 20, the approximate quantiles of T_1 are normally distributed [Ref. 10 : p. 218]. The result from equation 4 and the 0.05^{th} quantile of a standard normal random variable are in Table 8. Since T_1 is less than $T_{critical}$ the null hypothesis is rejected at a significance level of 0.05. The second test did in fact result in a higher average scores across all mental categories. The indication is that perhaps training does have a positive impact on cognitive ability.

Table 8. MANN-WHITNEY TEST RESULTS

T_1	$T_{critical}$	α Level	H_0
-2.70	-1.65	0.05	Rejected

Next, consider the CAT IIIB and CAT IV results. Of the twelve CAT IIIB and IV leaders retested, only one did not increase his score. On the average, both CAT IIIB and IV leaders increased their test scores by 8%. Table 9 below shows the difference in the scores achieved by the CAT IIIB and CAT IV leaders.

Table 9. CAT IIIB AND CAT IV TEST RESULTS

Mental Category	First Test Score	Second Test Score	Change
CAT IIIB	114	118	0.03
	109	120	0.07
	114	138	0.16
	117	133	0.11
	118	124	0.04
	108	130	0.15
	129	128	-0.01
Average	0.77	0.85	0.08
CAT IV	112	122	0.07
	110	133	0.15
	117	138	0.14
	116	120	0.03
	115	120	0.03
Average	0.76	0.84	0.08

V. RESULTS AND CONCLUSIONS

A. SUMMARY OF THE RESULTS

The results that are shown throughout the paper and summarized below are the product of a cognitive skills test developed by the author and a subjective scoring system developed by an expert infantryman. These results, although potentially global in nature, are applicable to this research project only.

B. INFLUENTIAL VARIABLE RESULTS

The first objective of this research is to determine, through regression techniques, which variables most influence a person's ability to make good decisions. The assumption is that as certain variables increase numerically, the associated score on the cognitive test, which is a measure of one's decision making ability, will also increase. For example, as time in service increases, the intuitive assumption is that one's capability to make sound military decision also increases. In other words, military experience level has a positive correlation with decision making skills. The backward stepwise regression shows that AFQT is the only variable with a large influence on decision making skill as measured by test score. AFQT alone accounts for over 50% of the variability in the regression model. When regressed against the dependent variable test score, the ANOVA results show that the slope of the regression line due to AFQT was definitely not zero.

C. DIFFERENCE AMONG MENTAL CATEGORY RESULTS

Given that AFQT is a strong indicator of decision making ability, the second objective is to determine if significant differences are observed between test scores from the various mental categories. By means of a Kruskal-Wallis test for different sample averages and a multiple comparison test, scores from CAT IIIB and CAT IV mental category leaders are found to be statistically different from the scores of CAT I and CAT II leaders. CAT IIIA leader scores are not statistically different from either the upper or lower category scores.

D. RESULTS OF THE COMPARISON BETWEEN THE FIRST AND SECOND TESTS

The third objective of the research is to determine if training can make up for the mental category test differential. By use of a Mann-Whitney test for equal averages

among two sample populations, the average of the second set of test scores is found to be statistically higher than the average of the first set of scores. Comparing just the CAT IIIB and IV average scores, an increase of 8% is found.

E. CONCLUSIONS

The fact that AFQT score has a strong positive relationship with the total scores on the cognitive test means that leaders with more raw mental ability are better able to make good military decisions. This is turn implies that soldiers with high AFQT scores are better able to accomplish the mission while protecting their limited resources. In short, high quality leaders are more efficient on the battlefield. In terms of this research, they are about 13% better than low quality (CAT IIIB and IV) leaders. The policy of recruiting high quality people has and will continue to pay dividends from a decision making ability point of view.

It was clear from the results of the second test that performance across all mental categories improves as evidenced by the overall increase in test scores and particularly the test scores of CAT IIIB and CAT IV leaders. What was not clear was how much of that increase is attributable to BNCOC instruction and how much to other factors such as familiarity with the test. Because 90% of the lower mental category soldiers scored higher on the second test, it is not likely that the increase is due to chance. If that were the case, one would expect an approximately equal number of lower and higher scores. The reason the increase in performance can be attributed to BNCOC instruction is because the best answer to each of the test questions is never known by any of the test subjects. In order to score higher on the second test, the leader must change his previous poor decision in favor of better decisions, and in order to do that consistently, he must have additional information. That information comes from the tactics classes taught during the six-weeks between test dates. This indicates that it is the training that is making up for the mental differences.

F. RECOMMENDATIONS

Because of the apparent success of the pilot test, further research should be conducted to verify the results of this project. It would be quite easy to adapt an appropriate combat scenario to a modern combat simulator such as the JANUS model in order to further define the measures of effectiveness. For example, using such a simulator, one could determine how much more effective smarter soldiers are in terms of tank equivalent kills or force ratios.

The apparently strong relationship between mental ability and performance leads to two other recommendations. First, because of pending constraints on the Army personnel strength, recruiting of all CAT IV quality soldiers should be terminated. Secondly, the ASVAB test should be given to all newly commissioned officers so that the same type of investigation can be conducted with the officer corps. The correlation between mental ability and performance applies to enlisted soldiers and should also apply to the officers.

APPENDIX A. TEST PACKET

A. PLATOON LEVEL COGNITIVE SKILLS TEST

1. Introduction:

This is a pilot test designed to collect data on cognitive or "thinking" abilities. The results will help identify which variables most influence the ability to make good decisions. The test consists of a scenario, where ten decisions must be made, and a short questionnaire. Please answer all questions by circling the number of the decision you feel is the best. There are no wrong answers. Pay attention to any guidance given and use your current SOP in the absence of guidance. Do not write your name on the test.

START TIME _____

FINISH TIME _____

2. General Situation

You are the acting platoon leader of 1st platoon, Company A, 10th Battalion, 100th Infantry (Light). Your battalion is currently refitting in an assembly area. Your platoon is fully equipped, at 95% strength, and morale is high. You are ready for combat! In addition, your platoon has an artillery forward observer attached.

The company commander has just returned from the battalion TOC. He gives the following briefing to all the platoon leaders.

"The battalion has been ordered to conduct a movement to contact to secure a group of bridges across the Diamond river. The river is about 10 km from this assembly area. Company A will lead and secure bridge 15 in the center. Because of an upcoming Brigade offensive the bridges must be taken intact and held for up to 3 days. We must take the bridge by midnight tomorrow (18 hours from now). Because this is an important mission the brigade has given our battalion priority of fires from our supporting artillery and additional airlift assets. There is also an attack helicopter company standing by to help but because we don't want the enemy to know what we are up to, use of helicopter assets will be reserved for emergencies. Our priorities for this mission are:

1. Above all, to take and hold the bridge.
2. Avoid contact with the enemy if possible, we will need every man to defend the bridge.
3. Time is critical to the brigade mission, so taking the bridge as quickly as possible is important.
4. The size and type of enemy forces we come across will dictate tactical decisions, but do not engage a force you cannot defeat quickly.
5. Terrain in our sector is wooded, gently rolling hills, with good cover and concealment. There are no natural obstacles between us and the river. Except for the bridge do not plan to hold any other terrain unless the situation requires.

The enemy in the battalion's sector consists of an airborne battalion that is currently east of the river refitting. We can expect to see at least patrol activity but he understands the importance of the bridges and will fight to retain them or destroy them as need be.

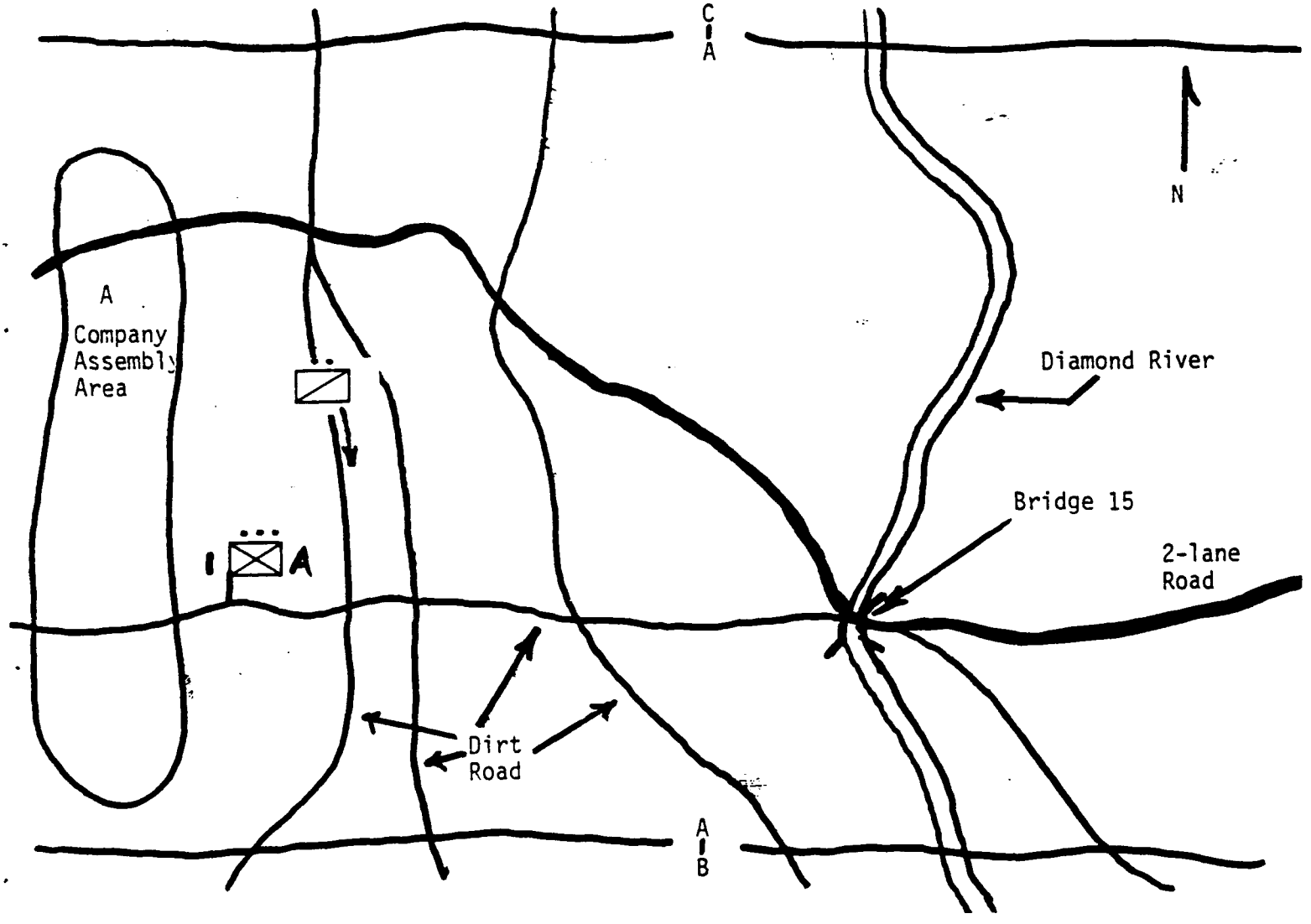
1st platoon, you are the lead element, LD time is one hour from now."

3. Special Scenario

A. Your unit has crossed the LD on time and has covered about 1 km when your lead element reports spotting a enemy recon element about 2 km in front (see diagram below). You order the platoon to halt while you move forward. You observe the

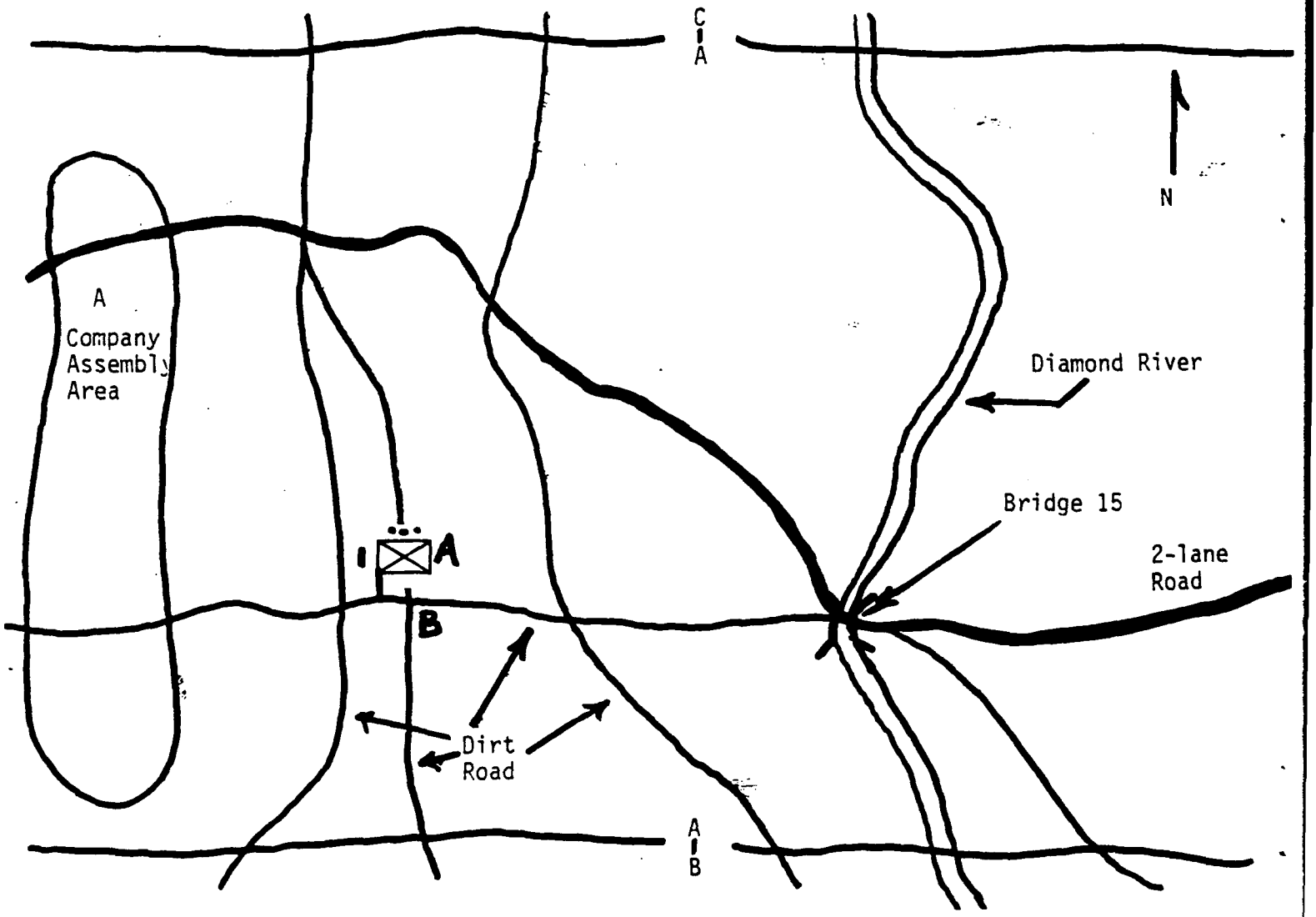
enemy moving north to south on the road directly in front of your platoon. You order the platoon to:

1. Bypass the enemy by changing your route to move more to the north.
2. Continue on current route, engage the enemy if necessary, and destroy him.
3. Temporarily halt, call in indirect fire on the patrol, then continue on the same route.
4. Temporarily halt, wait for recon element to pass, then continue on the same route.



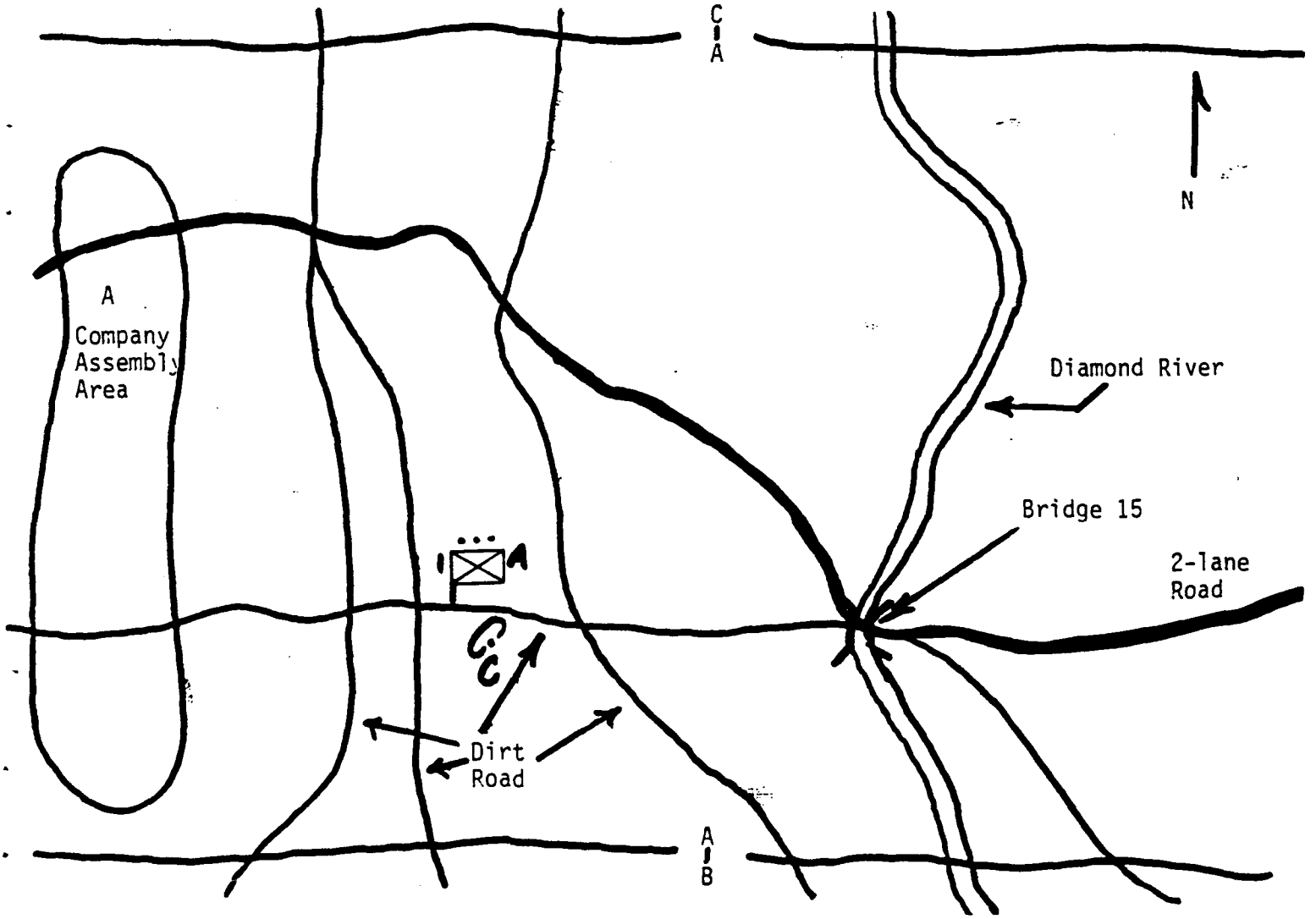
B. The platoon has moved another kilometer toward the objective when Sgt Brown reports his squad has halted at a road junction (labeled B below). He wants you to come forward. What you find is a HUMMV that apparently has hit a mine and you have no idea how far the minefield runs in either direction. You notify your commander that you intend to:

1. Find a way around the minefield and notify him of the safe route.
2. Breach the minefield with the platoon assets.
3. Establish hasty defense and request engineer support to breach the minefield.
4. Establish hasty defense and call in mortar fire on the road junction. Then cross where the mortar shells hit the road.



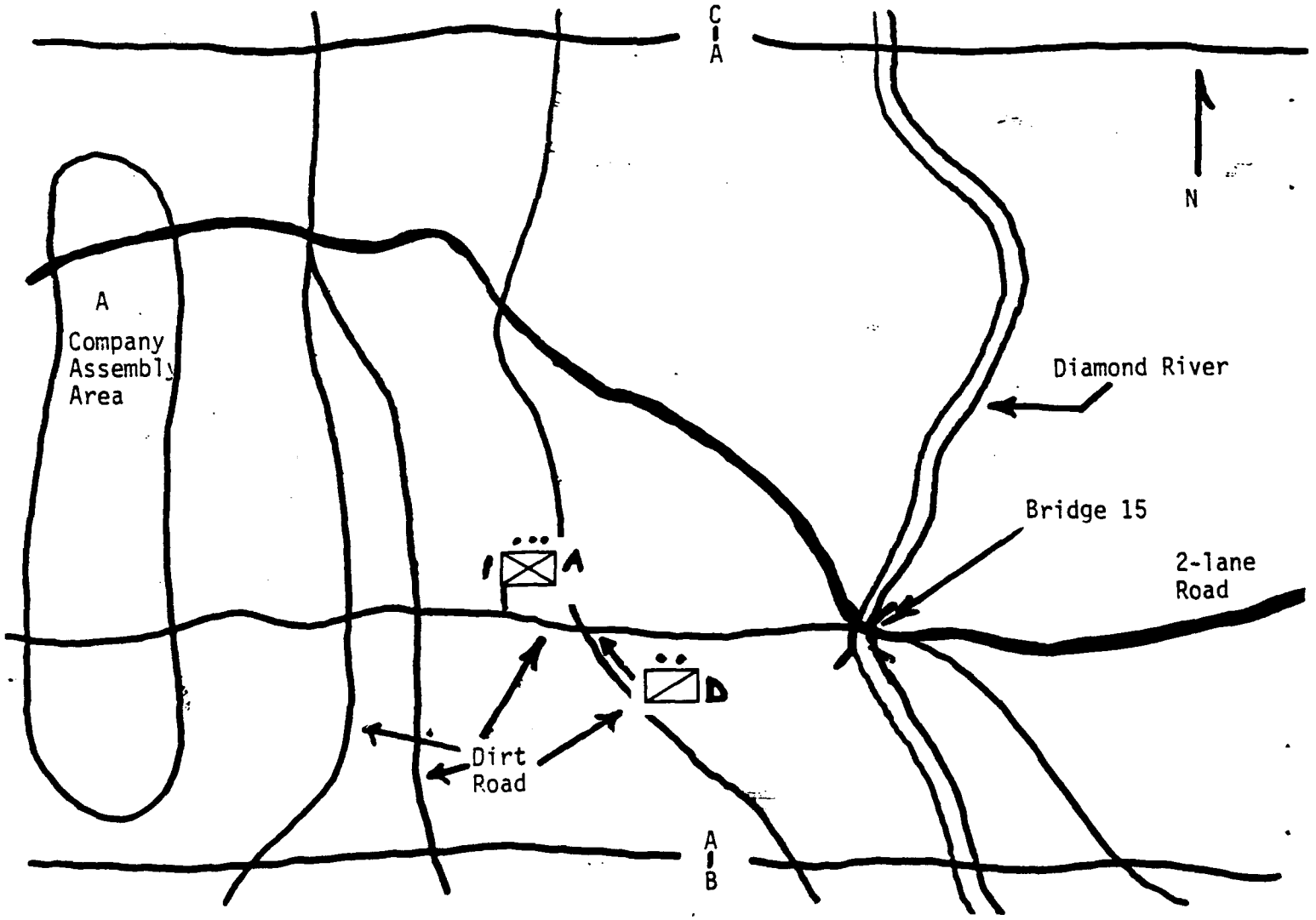
C. The platoon is past the mined road junction and back on the march when it comes under direct fire from an enemy outpost that was overwatching the minefield (labeled C below). Your lead squad is pinned down by sporadic small arms fire. There is one man with a minor wound. You have no time to discuss this with the commander so you order the platoon to:

1. Return fire and assault the enemy position.
2. Return fire and establish a hasty defense while you call in indirect fire.
3. Return fire, disengage, and bypass the enemy by going north.
4. Return fire, call in indirect fire, disengage, and bypass the enemy by going north.



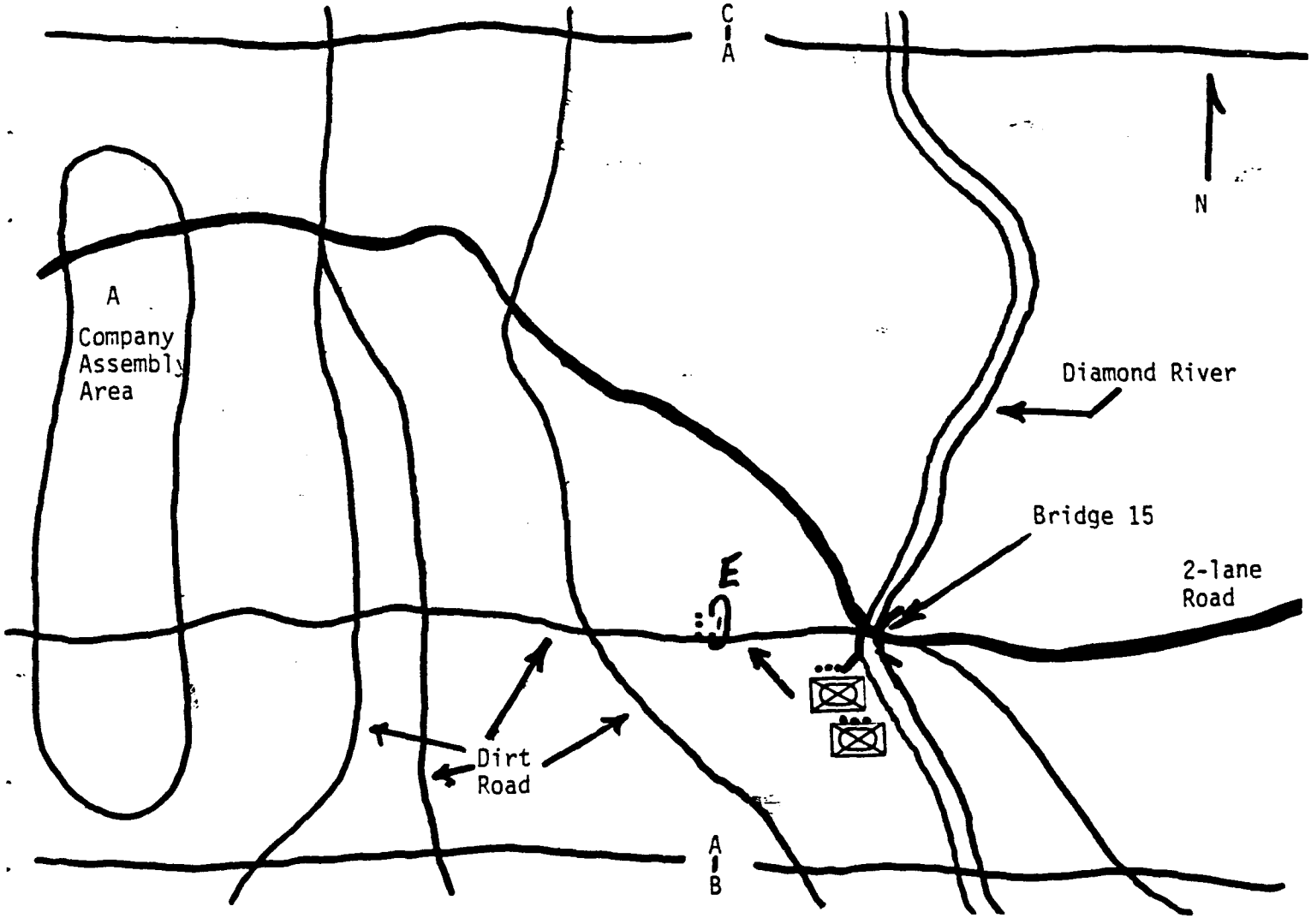
D. The platoon has passed the enemy outpost and is now about 5 kilometers from the river. You have temporarily halted to get everyone settled down and reorganized. The small-arms fire at the minefield has alerted the enemy patrol you saw earlier. They are coming back to find you by slowly searching along the road that runs north-south directly in front of the platoon (labeled D below). The patrol consist of two BRDM's. You estimate they will get to your position in about 5 minutes. You order the following:

1. Quickly cross the road, continue toward the bridge, and tell the CO about the patrol.
2. Call the CO and ask for help.
3. Set up an ambush and get rid of this patrol once and for all.
4. Fall back 300 meters, set up a hasty defense, and don't fire unless fired upon.



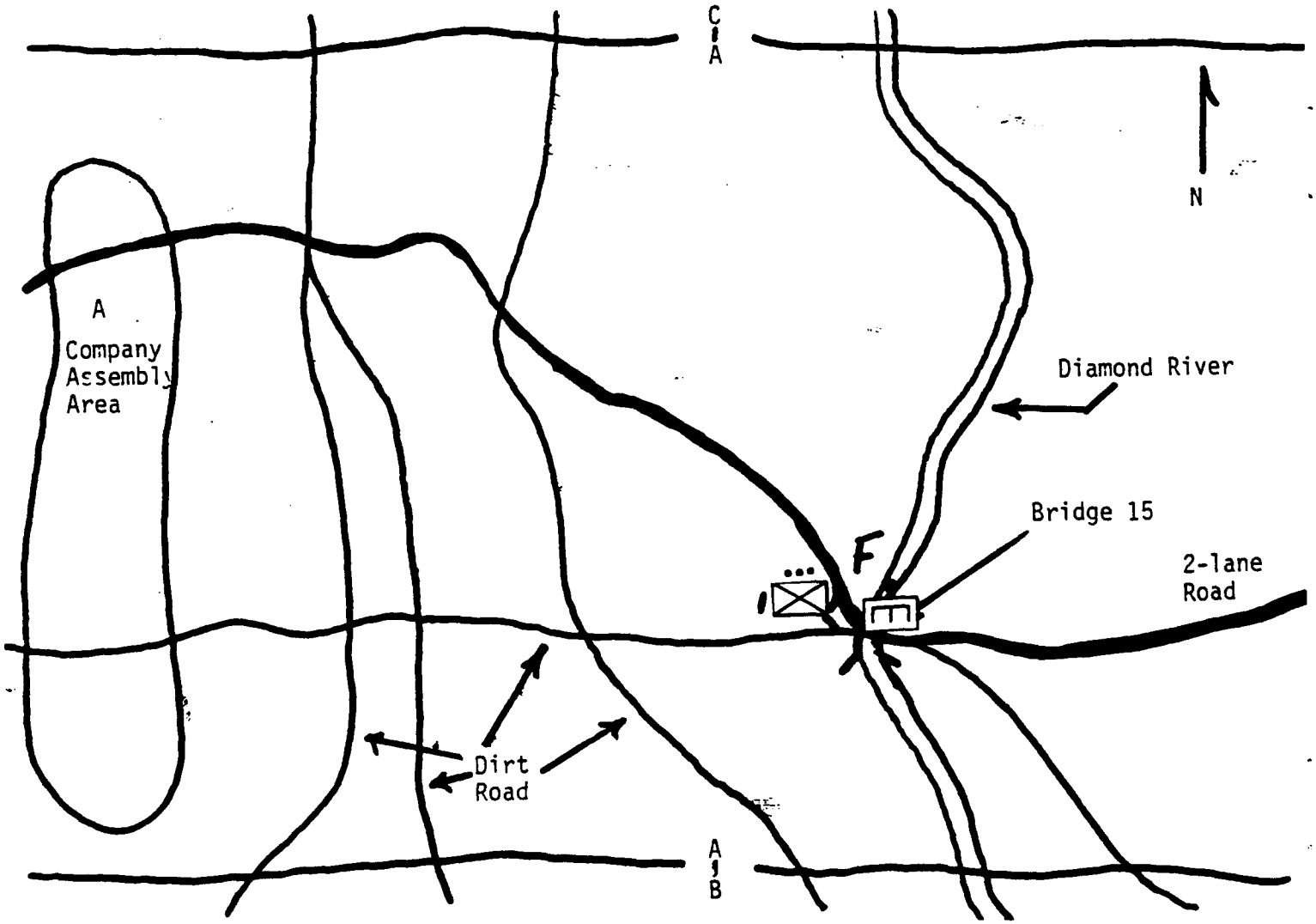
E. The next three kilometers of terrain have been crossed without incident. About 2 kilometers from the bridge the CO orders you to halt and set up a hasty defense so that the rest of the company can catch up (labeled E below). As defensive preparation is finishing you spot 8 BMPs slowly moving across the valley floor right toward your position. You try to reach the CO but after 3 unsuccessful attempts you do the following:

1. Order the platoon to dig in and prepare to defend this battle position.
2. Select an alternate battle position and move back to it.
3. Order the platoon to dig in while you call in indirect fire on the enemy platoons.
4. Call the 2nd platoon leader and ask for help, then order the platoon to dig in.



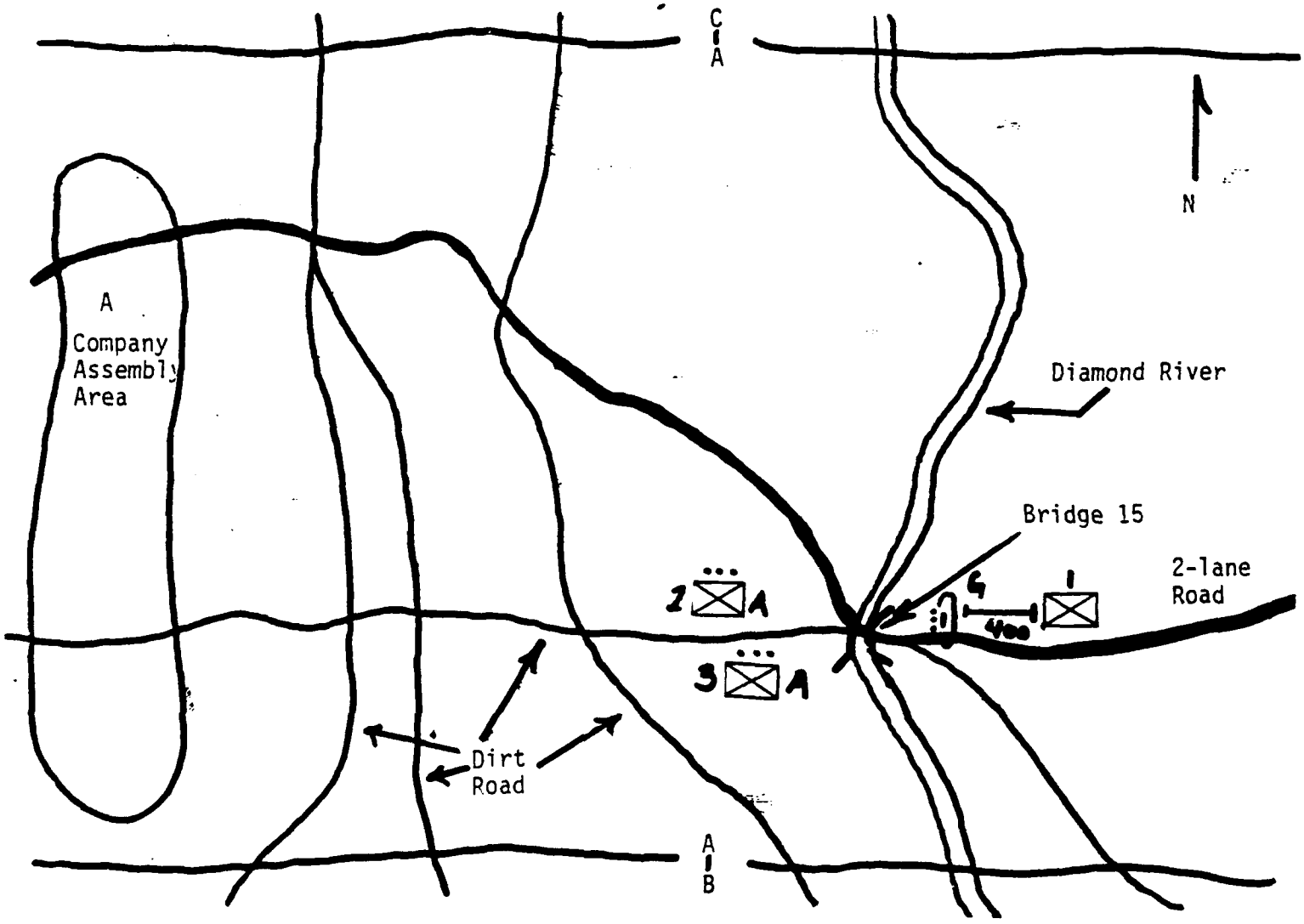
F. Before your decision can be implemented and for an unknown reason all 8 BMPs turn south and move away from your line of march. The CO finally comes back up on the radio and tells you to move out. In less than 30 minutes the bridge is in sight but an enemy dismounted infantry squad is rigging it for demolition. The bridge is 400 meters to your front (labeled F below). You decide on the following course of action:

1. Order the platoon to halt and establish a hasty defense while you call the CO to ask what to do.
2. Order the platoon to halt and establish a hasty defense while you call in indirect fire on the bridge.
3. Call in indirect fire and attack the bridge immediately.
4. Order the platoon to establish a hasty defense and fire on the enemy squad to hopefully drive them off the bridge.



G. Your platoon is now in a hastily prepared defensive position 350 meters east of the bridge (labeled G below). The rest of the company has not yet closed on the bridge but they are only 500 meters to the west. Sgt Jones of 2nd squad reports that a dismounted enemy infantry unit is coming toward the platoon location. He says he thinks it's at least a company size unit and they are 400 meters east (see diagram below). You take the following action(s):

1. Call the CO and ask for help, defend your position as long as possible, then select and move back to an alternate position on the east side on the river.
2. Call in indirect fire on the enemy company then move the platoon back to the west side of the river.
3. Order the platoon to dig in and defend your battle position.
4. Call in indirect fire on the enemy, prepare to defend your position, and call the CO and ask for help.

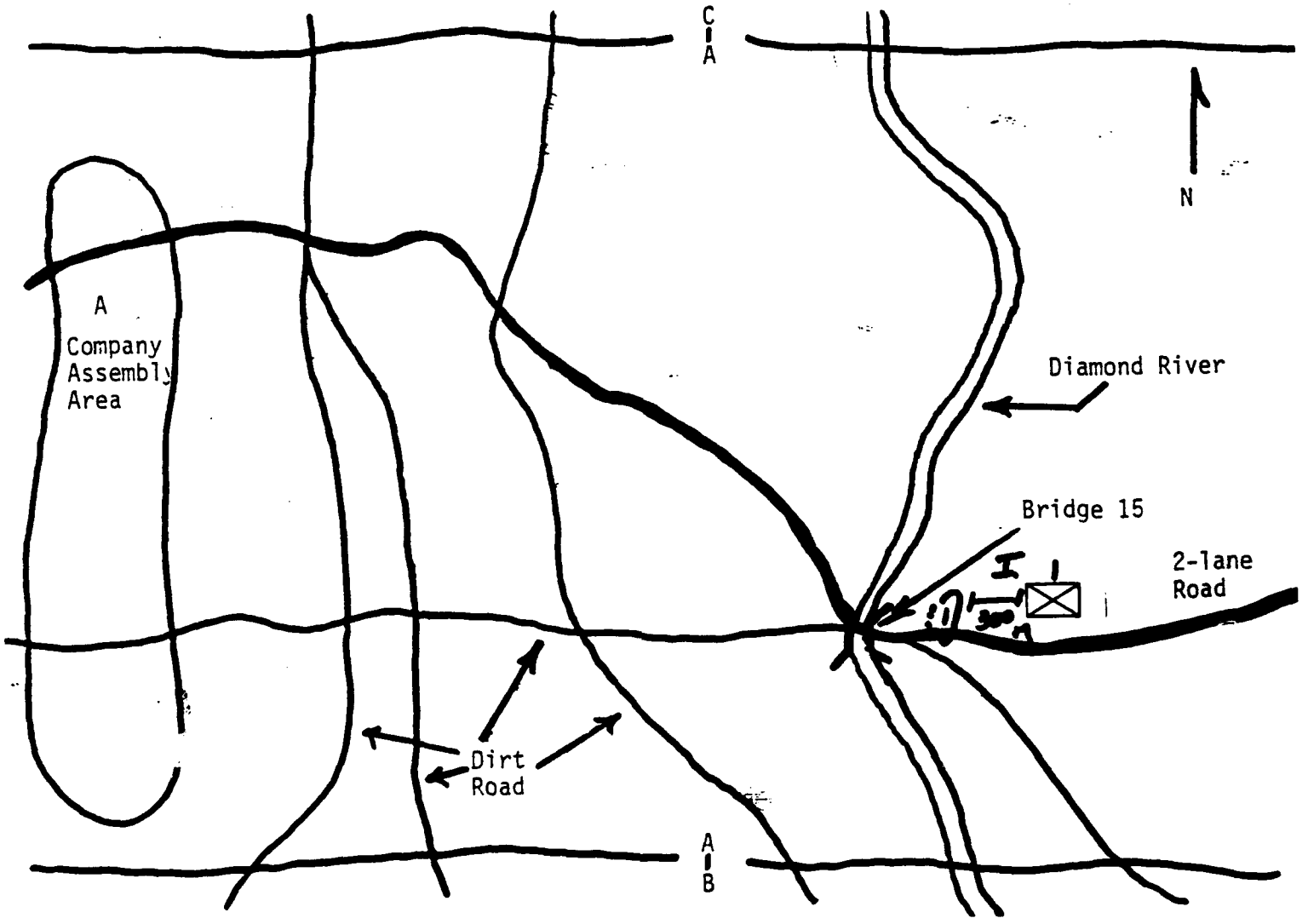


H. Before you get a chance to do anything, mortar rounds start falling on your position. You do the following:

1. Select an alternate position on the east side of the river and order the platoon to move back to that position.
2. Call in indirect fire on the enemy, call the CO and ask for help, then stay in position.
3. Call the CO and ask him what to do.
4. Call in indirect fire on the enemy then attack him.

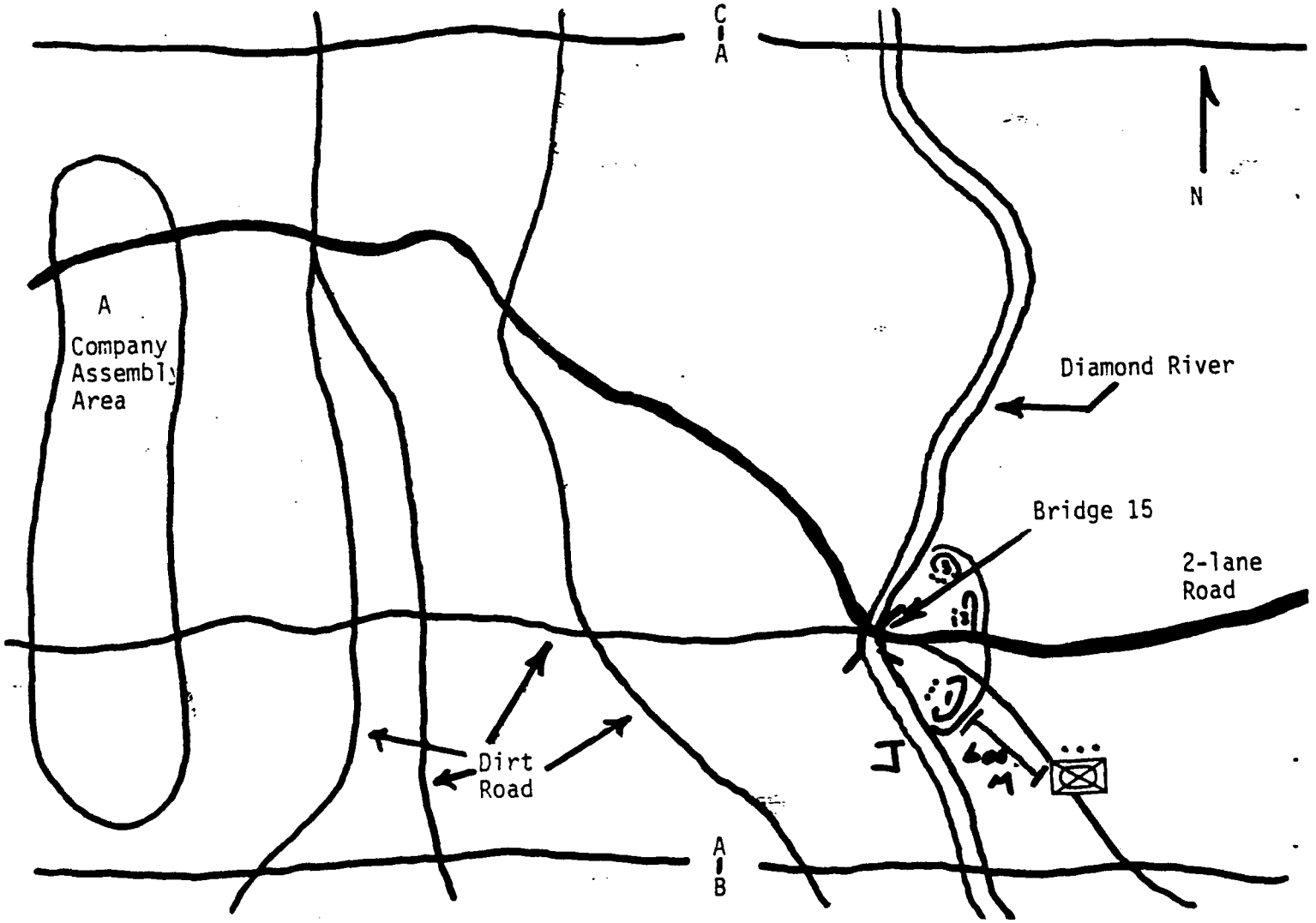
I. Just as you start to issue orders, 2 AH-64 Apache helicopters roar overhead and begin firing on the enemy company. The incoming mortar fire stops and you have some time to think. The enemy company has been pinned down and is about 300 meters from your position (labeled I below). You now do the following:

1. Tell the platoon to dig in while you call for indirect fire on the enemy company.
2. Call for indirect fire and attack the enemy company.
3. Call for indirect fire on the enemy then call the CO and ask what to do.
4. Select and move the platoon back to an alternate position east of the river.



J. As you are impiementing your decision the remainder of the company arrives. The CO orders your platoon to defend a battle position on the company's south flank (labeled J below). In 2 hours your position is completed. To the north, in the 2nd platoon area, you hear a fire fight break out. Five minutes later your observation post reports an enemy mechanized platoon (4 BMPs) moving northwest toward your position at a distance of 600 meters. You do the following:

1. Call the CO and ask for permission to move the platoon to your alternate position.
2. Call in indirect fire on the BMPs, defend the position as long as possible, then call the CO and get permission to occupy your alternate position.
3. Call the CO and tell him about the BMPs, then order the platoon to start firing on them to slow them down until help arrives.
4. Call in indirect fire on the BMPs, order the platoon to fire on them, and stay in your position.



B. PLATOON LEVEL COGNITIVE SKILLS TEST

1. Questionnaire

Please provide the information listed below.

1. Rank/grade _____

2. Social Security Number _____

3. Time in Service (in years and months) _____

4. Time in grade (in years and months) _____

5. Unit _____

APPENDIX B. SWANNACK SCORING SYSTEM

The scoring system for the platoon level cognitive test is based on the weighted factors of METT-T. Weights are determined by assigning a value to each factor from the scale in figure 1 (five being the highest and 1 the lowest weight). The total score for each alternative is the sum of the weighted factors of METT-T. Since terrain is difficult to simulate in a paper and pencil test, it will not be considered in any alternative. Weights for each factor are in brackets.

1----------2----------3----------4----------5

1 = Course of action will have a strong negative effect on this factor.

2 = Course of action will have a moderate negative effect on this factor.

3 = Course of action will have no effect on this factor.

4 = Course of action will have a moderate positive effect on this factor.

5 = Course of action will have a strong positive effect on this factor.

Figure 8. Test Weighting Scale

A. Your unit has crossed the LD on time and has covered about 1 km when your lead element reports spotting a enemy recon element about 2 km in front (see diagram below). You order the platoon to halt while you move forward. You observe the enemy moving north to south on the road directly in front of your platoon. You order the platoon to:

1. Bypass the enemy by changing your route to move more to the north.

Mission
1----------2----------3----------[4]---------5
Enemy
1----------2----------3----------[4]---------5
Troops Available
1---------[2]---------3----------4----------5
Time
1----------2---------[3]----------4----------5

2. Continue on current route, engage the enemy if necessary, and destroy him.

Mission
[1]--------2----------3----------4----------5
Enemy
[1]--------2----------3----------4----------5
Troops Available

1---------[2]---------3----------4----------5

Time

1---------[2]---------3----------4----------5

3. Temporarily halt, call in indirect fire on the patrol, then continue on the same route.

Mission

1----------2---------[3]----------4----------5

Enemy

1---------[2]---------3----------4----------5

Troops Available

1----------2---------[3]----------4----------5

Time

1----------2----------3----------[4]--------5

4. Temporarily halt, wait for recon element to pass, then continue on the same route.

Mission

1----------2----------3----------4---- ----[5]

Enemy

1----------2----------3---------[4]---------5

Troops Available

1----------2---------[3]---------4----------5

Time

1----------2----------3---------[4]---------5

B. The platoon has moved another kilometer toward the objective when Sgt Brown reports his squad has halted at a road junction (labeled B below). He wants you to come forward. What you find is a HUMMV that apparently has hit a mine and you have no idea how far the minefield runs in either direction. You notify your commander that you intend to:

1. Find a way around the minefield and notify him of the safe route.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3---------[4]---------5

2. Breach the minefield with the platoon assets.

Mission
1----------2----------3---------[4]---------5
Enemy
1---------[2]---------3----------4----------5
Troops Available
1---------[2]---------3----------4----------5
Time
[1]--------2----------3----------4----------5

3. Establish hasty defense and request engineer support to breach the minefield.

Mission
1----------2----------3---------[4]---------5
Enemy
1---------[2]---------3----------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
[1]--------2----------3----------4----------5

4. Establish hasty defense and call in mortar fire on the road junction. Then cross where the mortar shells hit the road.

Mission
1---------[2]---------3----------4----------5
Enemy
[1]--------2----------3----------4----------5
Troops Available
1---------[2]---------3----------4----------5
Time
[1]--------2----------3----------4----------5

C. The platoon is past the mined road junction and back on the march when it comes under direct fire from an enemy outpost that was overwatching the minefield (labeled C below). Your lead squad is pinned down by sporadic small arms fire. There is one man with a minor wound. You have no time to discuss this with the commander so you order the platoon to:

1. Return fire and assault the enemy position.

Mission
1---------[2]---------3----------4----------5
Enemy
[1]--------2----------3----------4----------5
Troops Available
[1]--------2----------3----------4----------5
Time
1---------[2]---------3----------4----------5

2. Return fire and establish a hasty defense while you call in indirect fire.

Mission
[1]--------2----------3----------4----------5
Enemy
1---------[2]---------3----------4----------5
Troops Available
[1]--------2----------3----------4----------5
Time
[1]--------2----------3----------4----------5

3. Return fire, disengage, and bypass the enemy by going north.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3---------[4]---------5

4. Return fire, call in indirect fire, disengage, and bypass the enemy by going north.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3---------[4]---------5

D. The platoon has passed the enemy outpost and is now about 5 kilometers from the river. You have temporarily halted to get everyone settled down and reorganized. The small-arms fire at the minefield has alerted the enemy patrol you saw earlier. They are coming back to find you by slowly searching along the road that runs north-south directly in front of the platoon (labeled D below). The patrol consist of two BRDM's. You estimate they will get to your position in about 5 minutes. You order the following:

1. Quickly cross the road, continue toward the bridge, and tell the CO about the patrol.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3----------4---------[5]

2. Call the CO and ask for help.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2---------[3]---------4----------5

3. Set up an ambush and get rid of this patrol once and for all.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1---------[2]---------3----------4----------5
Time
1---------[2]---------3----------4----------5

4. Fall back 300 meters, set up a hasty defense, and don't fire unless fired upon.

Mission
1---------[2]---------3----------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
[1]--------2----------3----------4----------5

E. The next three kilometers of terrain have been crossed without incident. About 2 kilometers from the bridge the CO orders you to halt and set up a hasty defense so that the rest of the company can catch up (labeled E below). As defensive preparation is finishing you spot 8 BMPs slowly moving across the valley floor right toward your position. You try to reach the CO but after 3 unsuccessful attempts you do the following:

1. Order the platoon to dig in and prepare to defend this battle position.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2---------[3]---------4----------5

2. Select an alternate battle position and move back to it.

Mission
1---------[2]---------3----------4----------5
Enemy
1---------[2]---------3----------4----------5
Troops Available
1---------[2]---------3----------4----------5
Time
[1]--------2----------3----------4----------5

3. Order the platoon to dig in while you call in indirect fire on the enemy platoons.

Mission
1----------2----------3----------4---------[5]
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3---------[4]---------5

4. Call the 2nd platoon leader and ask for help, then order the platoon to dig in.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1---------[2]---------3----------4----------5

F. Before your decision can be implemented and for an unknown reason all 8 BMPs turn south and move away from your line of march. The CO finally comes back up on the radio and tells you to move out. In less than 30 minutes the bridge is in sight but an enemy dismounted infantry squad is rigging it for demolition. The bridge is 400 meters to your front (labeled F below). You decide on the following course of action:

1. Order the platoon to halt and establish a hasty defense while you call the CO to ask what to do.

Mission
1---------[2]---------3----------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
[1]--------2----------3----------4----------5

2. Order the platoon to halt and establish a hasty defense while you call in indirect fire on the bridge.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2---------[3]---------4----------5
Time
1---------[2]---------3----------4----------5

3. Call in indirect fire and attack the bridge immediately.

Mission
1----------2----------3 ------4---------[5]
Enemy
1----------2----------3---------[4]---------5
Troops Available
1---------[2]---------3----------4----------5
Time
1----------2---------[3]---------4----------5

4. Order the platoon to establish a hasty defense and fire on the enemy squad to hopefully drive them off the bridge.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2---------[3]---------4----------5
Time
1---------[2]---------3----------4----------5

G. Your platoon is now in a hastily prepared defensive position 350 meters east of the bridge (labeled G below). The rest of the company has not yet closed on the bridge but they are only 500 meters to the west. Sgt Jones of 2nd squad reports that a dismounted enemy infantry unit is coming toward the platoon location. He says he thinks it's at least a company size unit and they are 400 meters east (see diagram below). You take the following action(s):

1. Call the CO and ask for help, defend your position as long as possible, then select and move back to an alternate position on the east side on the river.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3---------[4]---------5

2. Call in indirect fire on the enemy company then move the platoon back to the west side of the river.

Mission
[1]--------2----------3----------4----------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2----------3---------[4]---------5
Time
[1]--------2----------3----------4----------5

3. Order the platoon to dig in and defend your battle position.

Mission
1----------2----------3----------4---------[5]
Enemy
1----------2----------3---------[4]---------5
Troops Available
1---------[2]---------3----------4----------5
Time
1----------2----------3---------[4]---------5

4. Call in indirect fire on the enemy, prepare to defend your position, and call the CO and ask for help.

Mission
1----------2----------3---------[4]---------5
Enemy
1----------2----------3----------4---------[5]
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2----------3----------4---------[5]

H. Before you get a chance to do anything, mortar rounds start falling on your position. You do the following:

1. Select an alternate position on the east side of the river and order the platoon to move back to that position.

Mission
1----------2---------[3]---------4----------5
Enemy
[1]--------2----------3----------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1---------[2]---------3----------4----------5

2. Call in indirect fire on the enemy, call the CO and ask for help, then stay in position.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1---------[2]---------3----------4----------5
Time
1----------2---------[3]---------4----------5

3. Call the CO and ask him what to do.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1---------[2]---------3----------4----------5
Time
1---------[2]---------3----------4----------5

4. Call in indirect fire on the enemy then attack him.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3----------4---------[5]
Troops Available
[1]--------2----------3----------4----------5
Time
1----------2---------[3]---------4----------5

I. Just as you start to issue orders, 2 AH-64 Apache helicopters roar overhead and begin firing on the enemy company. The incoming mortar fire stops and you have some time to think. The enemy company has been pinned down and is about 300 meters from your position (labeled I below). You now do the following:

1. Tell the platoon to dig in while you call for indirect fire on the enemy company.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3---------[4]---------5
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2---------[3]---------4----------5

2. Call for indirect fire and attack the enemy company.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3----------4---------[5]
Troops Available
[1]--------2----------3----------4----------5
Time
1----------2---------[3]---------4----------5

3. Call for indirect fire on the enemy then call the CO and ask what to do.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1---------[2]---------3----------4----------5
Time
1---------[2]---------3----------4----------5

4. Select and move the platoon back to an alternate position east of the river.

Mission
1---------[2]---------3----------4----------5
Enemy
[1]--------2----------3----------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
[1]--------2----------3----------4----------5

J. As you are implementing your decision the remainder of the company arrives. The CO orders your platoon to defend a battle position on the company's south flank (labeled J below). In 2 hours your position is completed. To the north, in the 2nd platoon area, you hear a fire fight break out. Five minutes later your observation post reports an enemy mechanized platoon (4 BMPs) moving northwest toward your position at a distance of 600 meters. You do the following:

1. Call the CO and ask for permission to move the platoon to your alternate position.

Mission
1---------[2]---------3----------4----------5
Enemy
[1]--------2----------3----------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
[1]--------2----------3----------4----------5

2. Call in indirect fire on the BMPs, defend the position as long as possible, then call the CO and get permission to occupy your alternate position.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2---------[3]---------4----------5
Troops Available
1----------2---------[3]---------4----------5
Time
1---------[2]---------3----------4----------5

3. Call the CO and tell him about the BMPs, then order the platoon to start firing on them to slow them down until help arrives.

Mission
1----------2---------[3]---------4----------5
Enemy
1---------[2]---------3----------4----------5
Troops Available
[1]--------2----------3----------4----------5
Time
1----------2---------[3]---------4----------5

4. Call in indirect fire on the BMPs, order the platoon to fire on them, and stay in your position.

Mission
1----------2---------[3]---------4----------5
Enemy
1----------2----------3----------4---------[5]
Troops Available
1----------2---------[3]---------4----------5
Time
1----------2---------[3]---------4----------5

APPENDIX C. PLATOON LEVEL COGNITIVE SKILLS TEST DATA MATRIX

AFQT	1ST TEST SCORE	2ND TEST SCORE	TIS	TIG	TIME	MOS
34	114	118	113	12	28	0
66	130	122	72	2	24	1
15	112	122	70	36	21	1
75	120	120	35	8	23	0
14	113	0	120	12	22	1
32	109	120	60	12	22	1
94	125	127	96	29	23	1
73	131	130	59	27	21	1
14	110	133	80	27	21	1
21	117	138	50	32	17	0
60	122	136	37	9	20	0
23	116	120	81	27	21	0
36	114	138	113	48	17	1
69	122	120	70	12	25	1
50	113	117	114	24	19	0
37	117	133	48	6	19	0
42	118	0	34	7	19	0
60	128	125	81	33	11	1
91	136	0	91	15	21	0
94	130	131	102	26	20	1
42	130	124	76	4	16	1
33	108	130	24	27	17	1
48	129	128	47	5	15	0
57	125	133	63	38	15	1
47	120	0	81	26	12	1
69	112	133	54	6	12	1
99	135	144	75	43	18	0
76	135	119	96	40	20	1
26	115	120	67	11	24	1

APPENDIX D. BACKWARD STEPWISE REGRESSION DIAGNOSTICS

29 OBSERVATIONS R-SQUARED = 0.56447 STANDARD ERROR = 5.7262
2 VARIABLES ADJ R-SQUARED = 0.54834

					0.95 CONFIDENCE LIMITS	
COEF	ESTIMATE	STD ERR	T STAT	SIG LEVEL	LOWER	UPPER
INTERCEPT	107.96	2.4315	44.401	1.1102E-16	102.97	112.95
AFQT	0.25058	0.042361	5.9155	2.6442E-6	0.16366	0.3375

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	SIG LEVEL
INCLUDED	1	1147.4	1147.4	34.993	2.6442E-6
ERROR	27	885.3	32.789		
TOTAL	28	2032.7			

ANALYSIS OF NORMAL DISTRIBUTION FIT

DATA : RESIDUAL
SELECTION : ALL
X AXIS LABEL: RESIDUAL
SAMPLE SIZE : 29
CENSORING : NONE
FREQUENCIES : 1
EST. METHOD : MAXIMUM LIKELIHOOD
CONF METHOD : ASYMPTOTIC NORMAL APPROXIMATION

		CONF. INTERVALS (95 PERCENT)		COVARIANCE MATRIX OF PARAMETER ESTIMATES	
PARAMETER	ESTIMATE	LOWER	UPPER	MU	SIGMA
MU	2.3766E-14	-2.0114	2.0114	1.0527	0
SIGMA	5.5252E0	4.1029	6.9474	0	0.52634

	SAMPLE	FITTED
MEAN :	2.3766E-14	2.3766E-14
STD DEV :	5.6230E0	5.5252E0
SKEWNESS:	-1.8422E-1	0.0000E0
KURTOSIS:	2.8285E0	3.0000E0

PERCENTILES	SAMPLE	FITTED
5:	-8.2305	-9.0901E0
10:	-7.4904	-7.0818E0
25:	-2.9823	-3.7250E0
50:	0.26132	5.5808E-7
75:	3.7765	3.7250E0
90:	7.9944	7.0818E0
95:	9.0107	9.0901E0

GOODNESS OF FIT

CHI-SQUARE : 0.081116
DEG FREED: 1
SIGNIF : 0.77579
KOLM-SMIRN : 0.087766
SIGNIF : 0.97882
CRAMER-V M : 0.028836
SIGNIF : > .15
ANDER-DARL : 0.1987
SIGNIF : > .15

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

CHI-SQUARE GOODNESS OF FIT TABLE

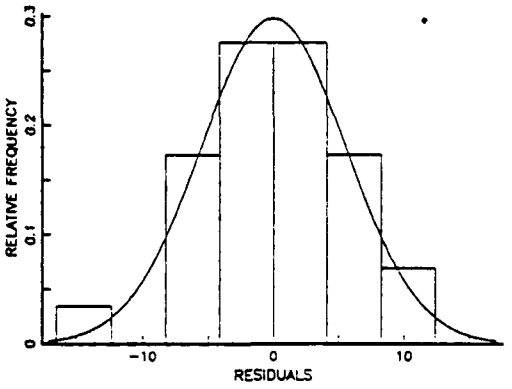
LOWER	UPPER	OBS	EXP	O-E	((O-E)*2)+E
-INF.	-4.1276	6	6.5979	-0.59793	0.054187
-4.1276	0	8	7.9021	0.097936	0.0012138
0	4.1276	8	7.9021	0.097928	0.0012136
4.1276	+INF.	7	6.5979	0.40207	0.024501
TOTAL		29	29		0.081116

SIMPLE CORRELATION COEFFICIENTS

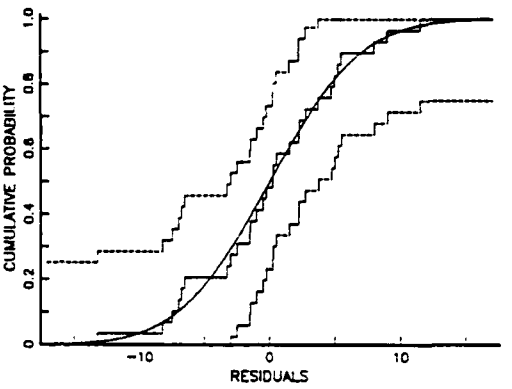
	AFQT	TIS	TIC	TIME	MOS	SCORE1
AFQT	1	0.050691	0.074288	-0.028023	-0.034462	0.75131
TIS	0.050691	1	0.33284	0.20882	0.20848	0.097378
TIC	0.074288	0.33284	1	-0.25107	0.22372	0.088791
TIME	-0.028023	0.20882	-0.25107	1	-0.1162	-0.095831
MOS	-0.034462	0.20848	0.22372	-0.1162	1	-0.06059

APPENDIX E. RESIDUAL ANALYSIS

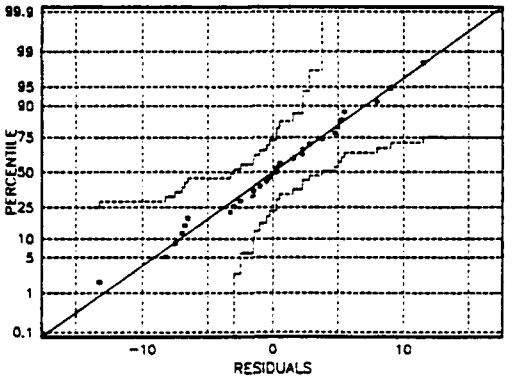
NORMAL DENSITY FUNCTION, N=29



NORMAL CUMULATIVE DISTRIBUTION FUNCTION, N=29



NORMAL PROBABILITY PLOT, N=29



ANALYSIS OF NORMAL DISTRIBUTION FIT

DATA	*RESR*
SELECTION	*ALL*
X AXIS LABEL	*RESIDUALS*
SAMPLE SIZE	29
CENSORING	*NONE*
FREQUENCIES	1
EST. METHOD	*MAXIMUM LIKELIHOOD*
CONF METHOD	*EXACT*

PARAMETER	*ESTIMATE*	*CONF. INTERVALS (95 PERCENT) LOWER*	*UPPER*
MU	1.5191E-14	-2.139	2.139
SIGMA	5.5252E0	4.4622	7.6052

COVARIANCE MATRIX OF PARAMETER ESTIMATES

	MU	*SIGMA*
MU	1.0527	0
SIGMA	0	0.52634

	SAMPLE	*FITTED*
MEAN :	1.5191E-14	1.5191E-14
STD DEV :	5.6230E0	5.5252E0
SKEWNESS:	-1.8422E-1	0.0000E0
KURTOSIS:	2.8285E0	3.0000E0

PERCENTILES	*SAMPLE*	*FITTED*
5:	-8.2305	-9.0901E0
10:	-7.4904	-7.0818E0
25:	-2.9823	-3.7250E0
50:	0.26132	5.5808E-7
75:	3.7765	3.7250E0
90:	7.9944	7.0818E0
95:	9.0107	9.0901E0

GOODNESS OF FIT

CHI-SQUARE :	-0.081116
DEG FREED:	1
SIGNIF :	0.77579
KOLM-SMIRN :	0.087766
SIGNIF :	0.97682
CRAMER-V M :	0.028836
SIGNIF :	> .15
ANDER-DARL :	0.1987
SIGNIF :	> .15

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS.

APPENDIX F. MULTIPLE COMPARISON APL FUNCTION

```
      ∇ MCT
[1]   ⍝THIS FUNCTION DETERMINES WHICH PAIR OF MENTAL CATEGORIES
[2]   ⍝TEND TO DIFFER BASED ON A REJECTED NULL HYPOTHESES FROM
[3]   ⍝A KRUSKAL-WALLIS TEST
[4]   ⍝ASSIGN A RANK TO EACH DATA POINT IN THE DATA SET
[5]    RCAT1← 19.5 24 27.5
[6]    RCAT2← 24 15.5 26 17.5 29 4.5 27.5
[7]    RCAT3A← 17.5 6.5 21 19.5
[8]    RCAT3B← 8.5 2 8.5 12.5 14 24 1 22 15.5
[9]    RCAT4← 4.5 6.5 3 12.5 11 10
[10]  ⍝SUM THE RANKS OF EACH MENTAL CATEGORY
[11]   RI←(+/RCAT1),(+/RCAT2),(+/RCAT3A),(+/RCAT3B),(+/RCAT4)
[12]  ⍝ENTER THE NUMBER OF OBSERVATIONS IN EACH MENTAL CATEGORY
[13]   N1←3
[14]   N2←7
[15]   N3A←4
[16]   N3B←9
[17]   N4←6
[18]   NI←N1,N2,N3A,N3B,N4
[19]   N←+/NI
[20]  ⍝COMPUTE S SQUARED
[21]   SUMR2←(+/RCAT1*2)+(+/RCAT2*2)+(+/RCAT3A*2)+(+/RCAT3B*2)+(+/RCAT4*2)
[22]   S2←(1÷(N-1))×(SUMR2-((N×((N+1)*2))÷4))
[23]  ⍝ENTER CONSTANTS
[24]   T←11.478
[25]   TCRIT←2.064
[26]   K←5
[27]   RHS←TCRIT×(S2×((N-T-1)÷(N-K)))*0.5
[28]   II←1
[29]   JJ←II+1
[30]   ⎕←'MENTAL CATEGORY COMPARISON'
[31]  ⍝BEGIN COMPARISON COMPUTATIONS
[32]  LOOPII:→(II>4)/ALLDONE
[33]  LOOPJJ:→(JJ>5)/DONE
[34]   LHS←|((RI[II]÷NI[II])-(RI[JJ]÷NI[JJ]))
[35]   VS←RHS×((1÷NI[II])+(1÷NI[JJ]))*0.5
[36]   ⎕←II,JJ
[37]   ⎕←LHS,VS
[38]   JJ←JJ+1
[39]   →LOOPJJ
[40]  DONE:
[41]   II←II+1
[42]   JJ←II+1
[43]   →LOOPII
[44]  ALLDONE:
[45]   ⎕←'IF LEFT > RIGHT THE I,J PAIR OF POPULATIONS ARE DIFFERENT'
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